

**Federal Energy Management Program (FEMP)
Sample Measurement & Verification Plans
for
SuperESPC Projects**

Draft for Public Review

Prepared by
Schiller Associates
www.schiller.com

For

Lawrence Berkley National Laboratory

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BACKGROUND

The purpose of this document is to provide examples of measurement and verification (M&V) plans for common energy conservation measures (ECMs) in enough detail to meet the requirements described in the FEMP M&V Guidelines, Version 2.2. This document contains M&V plans for three measures, using Option A and B methods, at a fictitious federal office building. The ECMs include lighting, energy management and control system installation, and a chiller retrofit.

This document is intended to serve the following purposes:

- Provide examples of M&V plans for common ECMs, that comply with the requirements set forth in the FEMP M&V guidelines, Version 2.2¹, and
- Provide and promote use of a consistent format for M&V plans.

The measures and their M&V approaches included in these examples are:

1. Lighting Efficiency Measure – Option A, Method LE-A-01
2. Energy Management Control System Installation - Option B, Method GVL-B-01
3. Chiller Replacement Measure – Option B, Method CH-B-02

M&V Plan Template

The following are section headings that are used in these example M&V plans. Under each section heading is a description of the required information for the section. Use of these headings to describe the M&V goals, ECM details, and M&V activities, ensures project developers that their M&V plans are complete, and the activities are thoroughly described. In addition, use of the following template promotes consistency among M&V plans, which also facilitates the review process and speeds up contract execution.

M&V Plan Section Headings

Project-level components

Project Description

Project Savings and Costs

Responsibility Matrix

Schedule

Reports to be Prepared

Measure-level components

¹ FEMP M&V Guideline V 2.2 available at www.eren.doe.gov/femp/financing/measguid.html

Measure Description

M&V Approach

Assumptions

M&V Activities

 Baseline Period

 Post-Installation Period

Calculations and Adjustments

Metering Plan

M&V Plan Budget

Every M&V plan should contain project-level component and measure-level component descriptions. For projects with multiple ECMs, information under the project-level component headings may summarize information for all the ECMs, while M&V activities for each individual ECM are described under the measure-level component headings.

Following are descriptions of the contents of each section.

Project-Level Components

Project Description

Describe the goals of the agency for this project, which may be energy savings, acquisition of new equipment, comfort condition improvement, process improvement, etc. Describe the facility and site characteristics. Descriptions should include substantial detail about the building size, location, use, equipment, and typical energy consumption characteristics, etc. Describe the specific energy conservation measures (ECMs) planned, including a description of how each saves energy, water, or O&M costs. Applicable energy-efficiency or performance standards should be referenced.

Project Savings and Costs

For each ECM, state the energy and cost savings anticipated. Also state the expected costs for performing M&V activities. For projects with multiple ECMs, use of a table to show a summary of total energy and cost savings, and M&V costs anticipated for each ECM would be appropriate.

Responsibility Matrix

Discuss the important risks involved with this project, and the ECMs. Indicate the party responsible for managing the risks². A matrix was developed to facilitate identification of project risks, assess their potential impact, and clarify the responsible party for managing the risk. The matrix is included at the end of this background section, and is available electronically from www.ateam.lbl.gov/my. A column should be added to the table and filled in to describe the actual distribution of risks between the ESCO and the agency for the individual project.

Schedule

A project schedule that shows the schedule for ECM installation, M&V activities, and reporting intervals should be included. M&V activities include pre- and post-installation audits and inspections, and monitoring and analysis activities. Reporting milestones should be identified. These milestones include post-installation inspections or commissioning reports, and quarterly or annual M&V reports (depending on the terms of the delivery order). Use of a Gantt chart is recommended.

Reports to be Prepared

Details on the M&V reporting should specify frequency, format, and content of reports, including whether and how raw and/or compiled electronic data will be submitted.

2 See FEMP M&V Guidelines Version 2.2, Table 2.1 *ESPC Responsibility Issues* for additional information.

Measure-Level Components

Measure Description

Describe the ECM, including specific details about individual ECMs. State what savings will be claimed, including any ancillary savings. For equipment to be replaced or modified, describe its vintage, condition, usage or operational and maintenance history characteristics. Include equipment standards, if relevant.

M&V Approach

State which M&V option will be used for the specific ECM. Cite the FEMP M&V Option and method by name (from the most recent FEMP M&V Guidelines), and provide a general description of the approach.

Where possible, assess the accuracy of the chosen M&V method, and state the savings uncertainty (precision) and confidence level. At a minimum, identify the factors that are the most uncertain, or most difficult to quantify.

Assumptions

State all substantive assumptions associated with the ECM. These include baseline and post-installation assumptions which affect energy consumption, such as building occupancy schedules, equipment efficiencies, equipment operating strategies, load shapes, weather data to be used, etc. Related energy price schedules, facility staff labor rates, etcetera, should be referenced.

M&V Activities

State who will perform the M&V activities. Describe all activities for measuring and verifying the energy consumption both before and after the installation of the ECM:

Baseline Period

- Identify all variables that affect energy consumption.
- Describe how those variables will be quantified (e.g. information from maintenance logs, commissioning reports, manufacturer data, measurements, short- or long-term monitoring, assumptions).
- Provide equipment surveys that show where the equipment is located, their type, quantity, and any measured data. Include identifying information such as model numbers or serial numbers.
- Define critical factors characterizing the baseline conditions (such as comfort conditions, lighting intensities, and temperature set points).

Post-Installation Period

- Identify all variables that affect energy consumption; include details of those that will vary from the baseline case.

- Describe how those variables will be quantified; include what measurements will be made to estimate them.
- Provide equipment surveys that show where the new equipment will be located, their type, quantity, and any parameter values that will be measured. Include identifying information such as model numbers or serial numbers.
- Define critical factors characterizing the post-installation conditions (such as comfort conditions, lighting intensities, and temperature set points).
- Describe activities that will be performed periodically to ensure that the equipment is performing as intended, and has the potential to generate the intended savings. Indicate frequency and nature of verification activities.

Calculations and Adjustments

Show the equations, calculations, and analysis procedures that determine the baseline consumption and the post-installation consumption. Include a description of how any models will be developed, and what physical equations will be used. State how energy savings for the ECM will be calculated.

If adjustments are necessary, such as when building occupancy schedules change, or temperature set points have been changed, state how the baseline energy values may be adjusted by using post-installation parameters if required. Show the equations to be used in the case that adjustments are necessary.

Metering Plan

The metering plan should state who will provide and maintain any metering equipment. Details should include specifications of equipment that will be used for taking measurements or conducting metering, accuracy of equipment to be used, calibration procedures that will be followed, and how the data will be collected, maintained, and reported. Data accuracy and quality assurance procedures should also be identified.

M&V Plan Budget

ESCOs should show estimates of the time and material costs to implement the M&V activities described for each ECM.

M&V Plan Content Requirement Checklist

To facilitate development of M&V plans, a checklist has been developed. Use the checklist to determine if all the necessary information has been included in the M&V Plan. A copy of the checklist is provided here. This list does not need to be included in an M&V plan but is included here for reference.

M&V Plan Content Requirement Checklist

FIGURE 0-1: CONTENT REQUIREMENT CHECKLISTS FOR M&V PLAN (FINAL PROPOSAL)³

- ☐ Project site and measures are defined.
 - ☐ What savings will be claimed? (Energy, interactive effects, O&M, rate change, etc.)
 - ☐ How will these ancillary savings be treated?
- ☐ M&V method(s) (chapters), from FEMP M&V Guideline, is defined.
- ☐ Details of how calculations will be made are defined. All equations are shown.
 - ☐ Provided information shows how collected data and assumptions are used.
 - ☐ Energy pricing information and assumptions are defined. (Fixed cost, inflated per EIA...)
- ☐ Baseline Equipment and Conditions.
 - ☐ Existing equipment (inventory and performance) is defined.
 - ☐ Space conditions (foot-candles, temps, etc.) are defined.
 - ☐ Assumptions and stipulations- show supporting information or measurements.
 - ☐ How and why any baseline adjustments will be made is discussed.
- ☐ Post-Installation Equipment and Conditions.
 - ☐ Plan for defining new equipment (inventory and performance) is described.
 - ☐ Plan for defining new space conditions (foot-candles, temps, etc.) is described.
 - ☐ Assumptions and stipulations-- show supporting information or measurements to be taken.
- ☐ Metering equipment is specified.
 - ☐ Schedule of metering, including duration and when it will occur, is defined.
 - ☐ Who will provide equipment, establish and ensure its accuracy and perform calibration procedures is described.
 - ☐ How data from metering will be validated and reported, including formats, are defined.
 - ☐ How electronic, formatted data, directly from a meter or data logger, will be provided.
 - ☐ Any sampling that will be used, sample sizes, documentation on how sample sizes were selected, is defined.
- ☐ Annual verification and measurement activities are defined.
 - ☐ Who will conduct the M&V activities and prepare M&V analyses and documentation is defined.
 - ☐ How quality assurance will be maintained and repeatability confirmed is defined.
 - ☐ Reports are defined, including what they will contain and when they will be provided.
 - ☐ Electronic formats and software programs to be used for reporting are defined.
- ☐ Initial and annual M&V costs for each measure (totals only).

3 From FEMP M&V Guidelines Version 2.2, Chapter 5

Clarification of Responsible Party” should be added and filled in with the agreed-upon allocation of risks between the ESCO and the Agency for the individual project.

Responsibility/Description
Financial
<u>Interest rates</u> Neither the ESCO nor the agency has significant control over the prevailing interest rate. During all phases of the project interest rates will change with market conditions. Higher interest rates will increase project cost, finance term, or both. The timing of the Delivery Order signing may affect the available interest rate and project cost. Clarify when the interest rate is locked in, and if it is a fixed or variable rate.
<u>Energy prices</u> Neither the ESCO nor the agency has significant control over actual energy prices. For calculating savings, the value of the saved energy may either be constant, change at a fixed inflation rate, or float with market conditions. If the value changes with the market, falling energy prices place the ESCO at risk of failing to meet cost savings guarantees. If energy prices rise, there is a small risk to the agency that energy saving goals might not be met while the financial goals are. If the value of saved energy is fixed (either constant or escalated), the agency risks making payments in excess of actual energy cost savings.
<u>Construction costs</u> The ESCO is responsible for determining construction costs and defining a budget. In a fixed-price design/build contract, the agency assumes little responsibility for cost overruns. However, if construction estimates are significantly greater than originally assumed, the ESCO may find that the project or measure is no longer viable and drop it. In any design build contract the agency loses some design control. Clarify design standards and the design approval process (including changes), and how costs will be reviewed.
<u>M&V costs</u> The agency assumes the financial responsibility for M&V costs directly or through the ESCO. If the agency wishes to reduce M&V cost, it may do so by accepting less rigorous M&V activities with more uncertainty in the savings estimates. Clarify what performance is being guaranteed (equipment performance, operational factors, energy cost savings), and that the M&V plan is detailed enough to satisfactorily verify it.
<u>Delays</u> Both the ESCO and the agency can cause delays. Failure to implement a viable project in a timely manner costs the agency in the form of lost savings, and can add cost to the project. Clarify schedule, and how delays will be handled.
<u>Major changes in facility</u> The agency (or Congress) controls major changes in facility use, including closure. Clarify responsibilities in the event of a premature facility closure, loss of funding, or other major change.
Operational
<u>Operating hours</u> The Agency generally has control over the operating hours. Increases and decreases in operating hours can show up as increases or decreases in “savings” depending on the M&V method (e.g. operating hours times improved efficiency of equipment vs. whole building utility analysis). Clarify if operating hours are to be measured or stipulated, and what is the impact if they change. If the operating hours are stipulated, the baseline should be carefully documented and agreed to by both parties.
<u>Load</u> Equipment loads can change over time. The agency generally has control over hours of operation, conditioned floor area, intensity of use (e.g. changes in occupancy or level of automation). Changes in load can show up as increases or decreases in “savings” depending on the M&V method. Clarify if equipment loads are to be measured or stipulated and what is the impact if they change. If the equipment loads are stipulated, the baseline should be carefully documented and agreed to by both parties.
<u>Weather</u> A number of energy efficiency measures are affected by weather. Neither the ESCO nor the agency has control over the weather. Changes in weather can increase or decrease “savings” depending on the M&V method (e.g. equipment run hours times efficiency improvement vs. whole building utility analysis). If weather is “normalized,” actual savings could be less than payments for a given year, but will “average out” over the long run. Weather corrections to the baseline or ongoing performance should be clearly specified and understood.

Responsibility/Description
<u>Life of equipment.</u> Equipment life is dependent on the original selection (contractor controlled), and operations and maintenance. Warrantees usually cover failures in the first year. Extended warrantees (often tied to service contracts) are available and assure that the agency won't continue paying for equipment that is no longer functional. Clarify who is responsible for repair and replacement of failed components throughout the term of the contract.
<u>User participation</u> Many energy conservation measures require user participation to generate savings (e.g. control settings). The savings can be variable and the ESCO may be unwilling to invest in these measures. Clarify what degree of user participation is needed, and utilize monitoring and training to mitigate risk. If performance is stipulated, document and review assumptions carefully, and consider M&V to confirm the capacity to save (e.g. confirm that the controls are functional).
Performance
<u>Equipment performance</u> Generally the ESCO has control over the selection of equipment and is responsible for its proper installation and performance. Generally the ESCO has responsibility to demonstrate that the new improvements meet expected performance levels including standards of service and efficiency. Clarify who is responsible for initial and long-term performance, how will it be verified, and what will be done if performance does not meet expectations.
<u>Maintenance</u> Responsibility for maintenance is negotiable, however it is often tied to performance. Clarify how long-term maintenance will be assured, especially if the party responsible for long-term performance is not responsible for maintenance.
<u>Operation</u> Responsibility for operation is negotiable, and it can impact performance. Clarify how proper operation will be assured. Clarify responsibility for operations and implications of equipment control.

**Measurement and Verification Plan
for the
Piscataway Federal Center**

**Provided in fulfillment of SuperESPC requirements,
Delivery Order Number XXIX34621**

**by
ABC Engineering, Inc.**

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Project contact information:

Arnold Buchstaubner
M&V Specialist
ABC Engineering, Inc.
24630 Corporate Road, Suite 3
Boulder CO, 80302
Phone (303) 988-1254
Fax (303) 988-1202
Email: axb@abceng.com

Richard Handy
Sr. Engineer
Dept. General Services
Federal Center Building
1800 Highrise Road
Piscataway NJ, 10012
Phone: (201) 455-3667
Fax: (201) 455-3439
Email: rihandy@piscataway.gsa.gov

1 PROJECT SPECIFIC INFORMATION

Project Description

The Federal Center, a 10-story office building in Piscataway, New Jersey, will participate in a FEMP SuperESPC project with ABC Engineering, the acting ESCO. The goal of this project is to modernize lighting and central plant equipment in the 40 year-old office building, and improve control of building equipment with the addition of an energy management control system (EMCS). This project will also produce improved lighting levels, and more reliable HVAC and central plant operation, thereby reducing maintenance costs. Although maintenance cost savings are anticipated for this project, payments will be based on energy cost savings only.

The Federal Center was built in 1958. It is located in downtown Piscataway, New Jersey, and houses several federal agencies. (This delivery order is with the Department of General Services.) It has approximately 300,000 total ft², the majority of which is office space. Lighting is provided by fluorescent lamps, in fixtures that were replaced approximately 20 years ago. Most existing light fixtures have T-12 lamps with magnetic ballasts. A central plant provides cooling to a constant-volume HVAC system. Heating is provided by zone perimeter hydronic baseboard heating. A 25 HP hot water pump is used to distribute the hot water, which is provided by a 9 MBTUH boiler. A 20 year-old, 400-ton chiller provides chilled water for the cooling system. An air handler located on the top floor has a 75 HP supply fan with a 50 HP return fan. A chilled water loop provides chilled water to the coils, using a 25 HP circulation pump. The chiller is served by cooling tower located on the roof. An additional 25 HP circulation pump provides condenser water to the tower.

Space temperature control is currently provided by setting thermostats in each zone manually. The building is fully occupied, with approximately 600 agency staff members. Occupants follow a regular schedule, with 8 am to 5 pm working hours during working days. The building is occupied from 6 am to 6 pm weekdays, from 9 am to 5 pm on Saturdays, and is not operated on Sundays and holidays. Staff from individual agencies are responsible for thermostat control, which results in inconsistent and uneven space conditions throughout the building. Some space thermostats are not set back during unoccupied times.

Utility bills for the period January to December 1999 are summarized in the following table

Table 1. Federal Center Monthly Utility bills (in \$1,000's)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Elect.	58.52	50.04	59.1	59.24	64.33	66.87	72.4	78.85	61.67	62.11	53.55	53.51	740.19
Gas	18.72	17.28	18.92	15.86	14.23	11.64	6.81	8.82	8.56	16.11	17.34	17.36	171.65
Total	77.24	67.32	78.02	75.1	78.56	78.51	79.21	87.67	70.23	78.22	70.89	70.87	911.84

Energy Conservation Measures (ECMs)

Lighting: A complete retrofit of the lighting equipment in the Federal Center is planned as a part of the ESPC agreement. The existing fixtures in this facility (1,745 total) will be replaced with more efficient equipment, primarily T8 lamps and electronic ballasts, thus reducing the electric demand and consumption of those areas retrofitted. Additional benefits include improved lighting levels, better color rendering, and reduced flicker.

EMCS: A new energy management and control system (EMCS) will be installed to provide enhanced control of HVAC systems. This system will provide energy and cost savings by

providing time of day control for the chiller, circulation pumps, and AHU fans. Savings from this measure will result from shutting off equipment when it is not needed.

Currently, large sized fan and pump motors (25 to 75 HP) operate at constant speed under manual control. The fan motors operate continuously, and the chiller and the pump motors also run for longer than required.

The control system will use an “optimum start” sequence to determine the start-up time for this equipment. This sequence will evaluate indoor and outdoor conditions and start the equipment accordingly so that proper set-points are reached prior to occupancy. The winter set-point (October – April) will be 68 °F, and the summer set-point (May – September) will be 72 °F.

Chiller: The Federal Center is cooled by a central chilled water plant utilizing a 400-ton constant-speed centrifugal chiller, which is 20 years old and has experienced significant degradation in performance. The chiller has a nominal efficiency of 0.748 kW/ton. This chiller will be replaced with an equivalent sized chiller that has a nominal efficiency of 0.53 kW/ton. The cooling tower was replaced 5 years ago, and will not be modified. The chilled water and condenser water pumps will be serviced, but not replaced. No other changes to the cooling plant will be made.

Project Savings and Costs

The project's total annual savings is estimated at 158 kW electric demand savings, and approximately 1,321,031 kWh electric consumption, for a total cost savings of \$84,582 annually. These are the total cost savings resulting from all ECMs. Only the direct savings from each ECM have been included, no interactive savings estimates or operational and maintenance savings were included. The individual ECM savings are described below.

Lighting. Savings from this ECM are projected to be 52 peak kW, 186,406 kWh, amounting to \$14,811 per year. The energy costs savings are 18% of the total cost savings for all ECMs installed at the Federal Center. Additional benefits to be realized by the agency include improved lighting levels in offices and hallways, and reduced maintenance related to lamp and ballast replacements.

EMCS. Annual savings from this ECM are projected to be 899,252 kWh, with cost savings of \$47,211. This represents 56% of savings from all ECMs installed in the Federal Center. Additional benefits to be realized by the Agency include: improved control of HVAC equipment and reduced operation expenses because of EMCS monitoring of equipment status.

Chiller. Annual savings from this ECM are projected to be 235,374 kWh and 106 kW peak demand, with annual cost savings of \$22,561. This represents 27% of savings from all ECMs to be installed at the Federal Center under this ESPC.

Below is a summary of this project's costs, estimated energy savings, and annual M&V costs. The costs shown are do not include all service phase margins, etcetera. Also included in the table are the M&V costs anticipated for this project, which do not include the costs for the first year activities (baseline analysis and post-installation report) which are estimated to be \$11,420, and are included as part of the detailed energy study. The ratio of total M&V costs to total project savings over the term of this delivery order is: $(\$11,420 + \$11,500 \times 12) / (98,417 \times 12) = 13\%$, which is within the range specified by the M&V Guidelines. Details of M&V costs are included in each ECM's M&V plan.

ECM	Direct Project	Savings	Average Annual	Annual M&V Costs ⁴
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	Project Cost	kW	kWh	Annual Cost Savings	Costs⁴
Lighting	\$87,397	52	186,406	\$14,811	\$2,320
EMCS	\$298,448	0	899,252	\$47,211	\$3,290
Chiller	\$323,544	106	235,374	\$22,561	\$5,890
Totals	\$709,389	158	1,321,031	\$84,582	\$11,500

Contractor mark-up, annual payments, and other financial details for this project are described in the H-schedules located elsewhere in the delivery order (DO). Payments are made to ABC Engineering in return for turnkey project implementation.

Energy Costs

Energy costs used to determine the value of the energy savings will be held constant over the contract term. The rates used to determine savings are those that the facility is paying as of January 2001. While the energy rates could have been escalated to account for inflation, it was decided to keep them constant over the contract term to remain conservative. If energy prices increase, then the agency will realize more savings than will be claimed. The agency also needs to realize that in the unlikely event that energy prices decrease, the energy saved will still be valued at these rates.

The Federal Building purchases both electricity and gas from Public Service Electric & Gas (PSE&G). Electricity is provided under rate schedule GS-1 and gas under schedule G-1. The following rates apply:

TABLE 1-1: ELECTRIC RATE SCHEDULE GS-1

Monthly charge	Cost per kWh (flat rate- no TOU charges)	Cost per kW-mo (no seasonal charges)
\$55	\$0.0525	\$8.052

TABLE 1-2: GAS RATE SCHEDULE G-1

Monthly Charge	Cost per million BTU
\$75	\$6.50

⁴ Costs do not include 1st year M&V costs

Responsibility/Description	Issue Discussion – Clarification of Responsible Party
Financial	
<p><u>Interest rates</u> Neither the ESCO nor the agency has significant control over the prevailing interest rate. During all phases of the project interest rates will change with market conditions. Higher interest rates will increase project cost, finance term, or both. The timing of the Delivery Order signing may affect the available interest rate and project cost. Clarify when the interest rate is locked in, and if it is a fixed or variable rate.</p>	<p>The final interest rate is fixed for the ten-year term of this contract at 8.78%, based on the signage of this delivery order by December 31, 1999.</p>
<p><u>Energy prices</u> Neither the ESCO nor the agency has significant control over actual energy prices. For calculating savings, the value of the saved energy may either be constant, change at a fixed inflation rate, or float with market conditions. If the value changes with the market, falling energy prices place the ESCO at risk of failing to meet cost savings guarantees. If energy prices rise, there is a small risk to the agency that energy saving goals might not be met while the financial goals are. If the value of saved energy is fixed (either constant or escalated), the agency risks making payments in excess of actual energy cost savings.</p>	<p>Energy prices for this DO have been set in Table 1-1 and Table 1-2 .. These rates are based on the current electric and natural gas costs for the Piscataway Federal Center, and are fixed for the term of the contract.</p>
<p><u>Construction costs</u> The ESCO is responsible for determining construction costs and defining a budget. In a fixed-price design/build contract, the agency assumes little responsibility for cost overruns. However, if construction estimates are significantly greater than originally assumed, the ESCO may find that the project or measure is no longer viable and drop it. In any design build contract the agency loses some design control. Clarify design standards and the design approval process (including changes), and how costs will be reviewed.</p>	<p>ABC Engineering takes responsibility for any variance that may occur in estimated and actual construction costs for all ECM presented herein.</p>
<p><u>M&V costs</u> The agency assumes the financial responsibility for M&V costs directly or through the ESCO. If the agency wishes to reduce M&V cost, it may do so by accepting less rigorous M&V activities with more uncertainty in the savings estimates. Clarify what performance is being guaranteed (equipment performance, operational factors, energy cost savings), and that the M&V plan is detailed enough to satisfactorily verify it.</p>	<p>The M&V costs have been estimated by ABC Engineering and are fixed for the duration of the contract. ABC Engineering accepts all risks associated with performing the M&V activities as stated herein.</p>
<p><u>Delays</u> Both the ESCO and the agency can cause delays. Failure to implement a viable project in a timely manner costs the agency in the form of lost savings, and can add cost to the project. Clarify schedule, and how delays will be handled.</p>	<p>No delays are expected based on the schedule presented herein. Should delays occur, any costs incurred by either party will be resolved through the negotiation process outlined in the RFP.</p>

Responsibility/Description	Issue Discussion – Clarification of Responsible Party
<p><u>Major changes in facility</u> The agency (or Congress) controls major changes in facility use, including closure. Clarify responsibilities in the event of a premature facility closure, loss of funding, or other major change.</p>	<p><u>Lighting.</u> Major renovations or additions to the facility could affect both the number of fixtures and their operating hours, with the possibility of causing the lighting energy costs to rise. No facility additions are planned at this time, however in the event that additions are made to the building, the Agency is still responsible for paying the energy cost savings as described in Schedule H.</p> <p><u>EMCS.</u> No facility additions are planned for this time, however in the event that changes are made to the building, the Agency is still responsible for paying the energy cost savings as described in Schedule H.</p> <p><u>Chiller.</u> Major renovations or additions to the facility may affect the operation of the new chiller. No facility changes are planned at this time, however in the event that the cooling load increases, the measured energy savings will also increase. If the annual run-time of the new chiller falls below the amount specified in the baseline, the GSA is still responsible for paying the energy cost savings as described in Schedule H.</p>
Operational	
<p><u>Operating hours</u> The Agency generally has control over the operating hours. Increases and decreases in operating hours can show up as increases or decreases in “savings” depending on the M&V method (e.g. operating hours times improved efficiency of equipment vs. whole building utility analysis). Clarify if operating hours are to be measured or stipulated, and what is the impact if they change. If the operating hours are stipulated, the baseline should be carefully documented and agreed to by both parties.</p>	<p><u>Lighting.</u> The agency has control over the hours of operation. Operating hours will be based on data from the monitoring activities described in this plan. The post-retrofit period operating hours will be stipulated to be the same as the baseline period. Should the Agency reduce operating hours, it will still be responsible to meet payments based on savings estimated with the stipulated operating hours.</p> <p><u>EMCS.</u> ABC Engineering will verify fan and pump motor operating hours for the baseline period, and will be responsible for setting temperature set-points and monitoring operating hours in the post-installation period.</p> <p><u>Chiller.</u> ABC Engineering has estimated the load on the facility based on short-term monitoring and historical log data. The GSA is responsible for maintaining similar operating hours and load conditions in the post-installation period. The GSA agrees that the chiller will be used annually for a minimum of 2,000 hours under full-load conditions.</p>

Responsibility/Description	Issue Discussion – Clarification of Responsible Party
<p><u>Load</u> Equipment loads can change over time. The agency generally has control over hours of operation, conditioned floor area, intensity of use (e.g. changes in occupancy or level of automation). Changes in load can show up as increases or decreases in “savings” depending on the M&V method. Clarify if equipment loads are to be measured or stipulated and what is the impact if they change. If the equipment loads are stipulated, the baseline should be carefully documented and agreed to by both parties.</p>	<p><u>EMCS</u>. No facility additions are planned for this time, however in the event that changes are made to the building, the Agency is still responsible for paying the energy cost savings as described in Schedule H.</p> <p><u>Chiller</u>. Major renovations or additions to the facility may affect the operation of the new chiller. No facility changes are planned at this time, however in the event that the cooling load increases, the measured energy savings will also increase. If the annual run-time of the new chiller falls below the amount specified in the baseline, the GSA is still responsible for paying the energy cost savings as described in Schedule H.</p>
<p><u>Weather</u> A number of energy efficiency measures are affected by weather. Neither the ESCO nor the agency has control over the weather. Changes in weather can increase or decrease “savings” depending on the M&V method (e.g. equipment run hours times efficiency improvement vs. whole building utility analysis). If weather is “normalized,” actual savings could be less than payments for a given year, but will “average out” over the long run. Weather corrections to the baseline or ongoing performance should be clearly specified and understood.</p>	<p><u>Chiller</u>. Although the operation of the new chiller may be affected by weather conditions, no weather corrections are to be performed. The chiller savings are based on the actual performance of the chiller, with a minimum number of operating hours agreed to as stated in the M&V plan.</p>
<p><u>Life of equipment</u>. Equipment life is dependent on the original selection (contractor controlled), and operations and maintenance. Warrantees usually cover failures in the first year. Extended warrantees (often tied to service contracts) are available and assure that the agency won’t continue paying for equipment that is no longer functional. Clarify who is responsible for repair and replacement of failed components throughout the term of the contract.</p>	<p><u>Lighting</u>. Normal lifetimes of lamps are 15,000 to 20,000 hours when connected to electronic ballasts. Electronic ballast lifetimes are expected to be from 5 to 8 years. ABC Engineering is responsible for replacement of failed, defective, or burned-out lamps and ballasts for the first contract year. The Agency is responsible for replacement of failed or burned-out lamps and ballasts after the first year.</p> <p><u>EMCS</u>. The fan and pump motors will not be changed as part of this project, only control of the motors will be added. The motors are expected to last throughout the term of this contract, but if they should fail, the Agency is responsible for their replacement and commissioning. Savings will be adjusted based on the new motor’s demand if the variance is more than 10% from the baseline value.</p>

Responsibility/Description	Issue Discussion – Clarification of Responsible Party
<p>User participation Many energy conservation measures require user participation to generate savings (e.g. control settings). The savings can be variable and the ESCO may be unwilling to invest in these measures. Clarify what degree of user participation is needed, and utilize monitoring and training to mitigate risk. If performance is stipulated, document and review assumptions carefully, and consider M&V to confirm the capacity to save (e.g. confirm that the controls are functional).</p>	<p>Lighting: The savings for the lighting project are based on the continuation of the current operating strategies for the lighting at the Piscataway Federal Center. This responsibility is accepted by the Agency.</p> <p>EMCS: The savings from the operation of EMCS is based on the control sequences outlined herein. Since these control sequences could be overridden by the facility operating staff, the Agency accepts responsibility that the EMCS will continue to operate as expected.</p>
Performance	
<p>Equipment performance Generally the ESCO has control over the selection of equipment and is responsible for its proper installation and performance. Generally the ESCO has responsibility to demonstrate that the new improvements meet expected performance levels including standards of service and efficiency. Clarify who is responsible for initial and long-term performance, how will it be verified, and what will be done if performance does not meet expectations.</p>	<p>Lighting. ABC Engineering has specified lamps and ballasts to provide energy savings and improved lighting conditions, therefore, for the first year, ABC Engineering is responsible for ensuring that the energy consumption and lighting levels of the new lamps and ballasts are as specified for the post-installation period. After the first year, the Agency assumes this responsibility.</p> <p>EMCS. The fan and pump motors are expected to draw power at a constant load as defined by measurements in the baseline period throughout the contract term. The Agency is responsible for maintaining the motors so that the power draw remains at the specified level.</p> <p>Chiller. The chiller is the only central plant equipment that has been replaced. The proper ongoing operation of the chillers is dependent on proper operation and maintenance of the related equipment. The chiller is expected to perform as rated by the manufacturer for the term of the contract. The GSA is responsible for maintaining all central plant equipment, including the chiller, for the duration of the contract. Chiller performance verification will be conducted by ABC Engineering during commissioning and checked annually for the duration of the contract.</p>
<p>Maintenance Responsibility for maintenance is negotiable, however it is often tied to performance. Clarify how long-term maintenance will be assured, especially if the party responsible for long-term performance is not responsible for maintenance.</p>	<p>The Agency accepts responsibility for the ongoing maintenance of all equipment affected by this DO. ABC Engineering will conduct annual inspections of the affected equipment, and will report any discrepancies and suggested remedies to the Agency immediately.</p>
<p>Operation Responsibility for operation is negotiable, and it can impact performance. Clarify how proper operation will be assured. Clarify responsibility for operations and implications of equipment control.</p>	<p>The Agency accepts responsibility for the ongoing operation of the equipment and systems affected by this DO, as described herein.</p>

Schedule

The following Gantt chart shows the first year activities for this project. Annual M&V activities recur each successive year, and commence on the same date as shown for the first year.

ID	Task Name	Start Date	End Date	1999	2000					2001				
				Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4		
1	Sign Delivery Order	1/3/00	1/3/00	◆										
2	Installation	3/19/00	6/30/00	▼										
3	Lighting	3/19/00	4/20/00	■										
4	EMCS	3/26/00	5/26/00	■										
5	Chiller	3/26/00	5/26/00	■										
6	Post-Installation Report	6/30/00	6/30/00	◆										
7	Agency Acceptance	8/1/00	8/1/00	◆										
8	Performance Period	8/1/00	8/1/01	▼										
9	Annual M&V Activities	8/1/01	9/30/01	▼										
10	Lighting	8/1/01	8/30/01	■										
11	EMCS	8/1/01	8/30/01	■										
12	Chiller	8/1/01	8/30/01	■										
13	Report	9/30/01	9/30/01	◆										
14	Agency Payment	10/1/01	10/1/01	◆										
15	Project Close-Out	11/1/01	11/1/01	◆										

Reports to be Prepared

Post-installation report. The post-installation report will be provided upon completion of installation and commissioning of the ECMs. After receipt of the post-installation report, the agency will perform inspections and issue ABC Engineering a written notification of approval.

The post-installation report will include documentation of:

- the lighting ballasts and lamps actually installed, and results of tests of each lighting circuit,
- documentation of the actual EMCS installed, and a summarization of the EMCS operation features in regard to control of the chiller pump and fan motors,
- documentation of the chiller manufacturer and model number, its ARI rated efficiency (in kW/ton) as well as findings from start-up and acceptance tests, and
- operation manuals for the EMCS and chillers.

The post-installation report will document any deviations from the specified equipment, and if necessary, make recommendations for approval of any adjustments to M&V plans specified herein.

Annual M&V reports. An annual Measurement and Verification Report (MVR) will be submitted to the General Service Administration within the first quarter of each year. The report will include the following ECM-specific information:

- Lighting. A report that details the results of annual inspections, noting significant problems such as burned-out lamps and ballasts, and deviations with the expected number of

operating fixtures, etc., and provide an estimate of energy and cost savings for the previous year.

- **EMCS:** A report that summarizes the results of calculations that determine the savings. Monitored data, and details of all calculations will be provided electronically, in MS Excel™ spreadsheets. An example spreadsheet format is provided in Figure 1-1.

FIGURE 1-1: EXAMPLE MONTHLY CALCULATION FORMAT – AHU1

Day	Measured Operating Hours – AHU1	kWh _{post}	kWh _{baseline}	kWh Savings
1				
2				
3				
...				
...				
Totals	Op.Hrs_{total}	kWh_{post total}	kWh_{baseline total}	kWh_{saved total}

- **Chiller.** A report that summarizes the calculated savings for the past year. Savings calculations will also be provided electronically, in MS Excel spreadsheets. All calculations will follow the procedure described in the chiller M&V plan, described herein. In addition to the reports, all monitored data will be submitted in electronic format for review by the owner.

The spreadsheet will show all intermediate steps in calculating baseline chiller kW, and show how energy savings will be determined. A sample spreadsheet format is provided in Figure 1-2.

FIGURE 1-2: SAMPLE FORMAT OF BASELINE CALCULATIONS

Time	ECWT, °F	LCWT, °F	TONS _t	CWT, °F	CAP _t	PLR _t	PLR _{adj}	Temp _{adj}	kW _{base}	kW _{post}	kW _{Saved}

Variable names are described in the chiller M&V Plan

2 ECM 1: LIGHTING EFFICIENCY RETROFIT – FEMP OPTION A, METHOD LE-A-01

Description of Energy Conservation Measure

A complete retrofit of the lighting equipment in the Federal Center is planned as a part of the ESPC agreement. The existing fixtures in this facility (1,745 total) will be retrofitted with more efficient equipment, primarily T8 lamps and electronic ballasts. Energy savings resulting from this retrofit are estimated to be 73 kW (connected load), 52 kW (billed demand reduction), and 186,406 kWh, amounting to \$14,811 per year. An additional benefit will be enhanced quality of lighting, as the new fixtures will provide more light improved, color rendering, and less flicker.

M&V Approach

The measurement and verification plan for the lighting efficiency retrofit at the Federal Center will follow the **FEMP M&V Option A, Method LE-A-01**. Fixture wattages will be determined from a standard table of wattages or from manufacturer's data, and annual operating hours will be stipulated based on short-term monitored data. The fixture wattage table referenced is from a TXU Electric program⁵.

Option A has been selected for this retrofit due to the measure's relatively small cost savings contribution of all the retrofits installed at the Federal Center, and due to the high confidence with which the fixture demand and operating hours may be determined. Equipment numbers and locations will not vary, and operating hours are not projected to change after the project is implemented.

Assumptions

The measurement and verification plan for this retrofit assumes:

- Operating hours for the lighting fixtures will be the same before and after the equipment retrofit.
- Fixture Wattages before and after the retrofit will be determined from a standard table of wattages (from TXU Electric) or from manufacturer's data.
- Interactive effects on heating and cooling equipment from the lighting retrofit will not be considered.
- Lighting levels will not decrease as a result of the lighting equipment retrofit. Existing lighting levels have been recorded for each area and are included in the equipment inventory.

M&V Activities

The measurement and verification activities that will be conducted for the baseline and post-installation periods are outlined below. ABC Engineering will conduct all M&V activities, unless otherwise indicated.

⁵ The lighting table may be found at: www.txu.com/teem/static/custom/wtable.htm

Baseline Period

During the Detailed Energy Survey, which took place during April 2000, a comprehensive lighting audit was completed. A room-by-room inventory of fixture counts, types and circuits was made. This inventory of all existing lighting equipment is provided in Attachment 1 to this M&V plan.

Fixtures in locations with similar operating hours were classified as a single usage group. Seven usage groups were identified, and are listed in Table 2-1. During the audit, the operating hours for a sample of lighting circuits in each usage group was measured over a three-week period. The monitored operating hours were used to estimate the annual operating hours for each group. The estimated operating hours will be stipulated as annual operating hours for the duration of the contract.

The maximum percentage of coincident operating hours (called the diversity factor) for each usage group was determined from this data and will be used for the duration of the contract to determine the demand cost savings.

Post-Installation Period

During installation of the fixtures and lamps, spot measurements of ballast and lamp model numbers will be checked on the TXU Wattage table and will be compared to the values specified for the fixture in that location. If more than 10% of the fixtures have greater than 10% deviations from the Wattage table values, the estimated post-installation wattage for the usage group will be adjusted. After the installation is completed, it will be inspected and approved by the Agency. Once per year, for each year of the contract, ABC Engineering will conduct a site visit, during which the lighting system will be inspected to verify the fixture counts and operation, and ensure that it has been maintained and continues to have the potential to generate the expected savings.

Calculations and Adjustments

The baseline and post demand for each usage group will be determined using Equation 2-1.

EQUATION 2-1:

$$\text{kW UsageGroup } U_{\text{baseline}} = \sum_u (\text{kW}_{\text{baseline fixture}})$$

$$\text{kW UsageGroup } U_{\text{post}} = \sum_u (\text{kW}_{\text{post fixture}})$$

Energy (kWh) and demand (kW) savings will be calculated using Equation 2-2. and Equation 2-1.

EQUATION 2-2:

$$\text{kWh Savings} = \sum_u [(\text{kW UsageGroup } U_{\text{baseline}} - \text{kW UsageGroup } U_{\text{post}}) \times \text{Annual Hours of Operation}]_u$$

EQUATION 2-3:

$$\text{kW Savings} = \sum_u [(\text{kW UsageGroup } U_{\text{baseline}} - \text{kW UsageGroup } U_{\text{post}}) \times \text{Diversity Factor}]$$

where:

kWh Savings = Kilowatt-hour savings realized during one year post-installation

kW Savings =	Coincident kilowatt demand saving realized
KW UsageGroup U_{baseline} =	Lighting baseline demand for usage group u
KW UsageGroup U_{post} =	Lighting demand during post-installation period for usage group u
Annual Hours of Operation=	Annual number of operating hours for the usage group u
Diversity Factor =	Maximum percent of lighting operating at one time, as determined from metered data from time-of-use loggers

The annual cost savings will be determined using Equation 2-4.

EQUATION 2-4:

$$\text{Annual Cost Savings} = [\text{Rate}_{\text{kWh}} \times \text{kWh Savings}] + [12 \times \text{Rate}_{\text{kW}} \times \text{kW Savings}]$$

where:

$\text{Rate}_{\text{kWh}} = \$0.0525/\text{kWh}$, and $\text{Rate}_{\text{kW}} = \$8.052/\text{kW}$.

As described in the responsibility matrix, no alterations or renovations to the office spaces are anticipated for the duration of this delivery order. Should the GSA make any improvements, it assumes the risk that the savings calculated by this plan may not materialize.

Metering Plan

Five separate usage groups have been identified. The usage groups were selected based on space functionality and estimated annual operation hours. Monitoring of operating hours was performed for three weeks during the Detailed Energy Survey. For usage groups that represented more than 5% of the savings, several fixtures were monitored to determine the typical operating hours. A sample of monitoring points for each usage group was determined by the following procedure:

1. A sample size will be chosen such that metering precision is expected to be 20% at 80% confidence.
2. Estimate the sample size n for the total population of lighting circuits using the following standard statistical equations for estimating sample populations⁶:

$$n^* = \frac{Z^2 C_v^2}{p^2}; \quad n = \frac{N n^*}{N + n^*}$$

where: $Z = 1.282$ for a confidence level of 80%, $p = 0.2$ for a precision level of 20%, C_v = the coefficient of variation, assumed to be 0.5. N is the total population of circuits for the building, n^* is the sample size required for an infinitely large population, and n is the sample size after correcting for a finite population.

6 Scheaffer, R., Menenhall, W., Ott, L., *Elementary Survey Sampling*, 4th ed. 1990, PWS-KENT, Boston, MA.

3. Using the demand savings and measured operating hours, estimate the annual energy savings from each usage group,
4. Groups that represent less than 5% of the expected energy savings will not be metered; operating hours will be determined through observation. However, sufficient usage groups will be monitored to account for at least 75% of the total energy savings.

The usage groups and metering requirements are shown in Table 2-1. The number of samples in the exit signs and other small groups were set to zero. The operating hours for the remaining groups were monitored for a three-week period in April – May 2000. The average operation hours for each usage group are shown, along with the actual C_v of each group. The table shows that the estimated C_v for the population was reasonable.

TABLE 2-1: USAGE GROUP DESCRIPTIONS AND REQUIRED MONITORING POINTS

Usage Group	# of Fixtures	# Circuits (N)	# Points (n)	Demand Savings, kW	Annual Operating Hours	Savings, kWh	% of total savings	Actual C_v
24 Hour - Exit	69	21	0	0.8	8,760	7,169	4%	-
24 Hour - Misc	30	9	5	1.8	8,760	15,598	8%	20%
Closed Office Areas	673	204	10	22.8	1,900	43,377	23%	65%
Common Office Areas	581	176	11	37.3	2,800	104,343	56%	23%
Conference Rooms	43	13	0	2.8	1,600	4,436	2%	-
Halls and Common areas	131	37	0	1.5	3,000	4,633	2%	-
Storage, comp. closets	218	66	0	5.7	1,200	6,850	4%	-
Totals	1,745	526	26	72.7		186,406	-	-

Bobo time-of-day lighting loggers⁷ (model BOBO-L-TOU) were used to meter run time and determine the maximum coincident percent of fixtures operating at any one time. The diversity factor was calculated to be 72%. These lighting loggers record the time-of-day the lights are turned on or off. The light threshold range is 10 to 300 lumens/ft² (fluorescent light); the sensitivity to incandescent light is about ten times greater. The lighting loggers record on-off times with an accuracy ± 1 minute per week.

Project Budget

⁷ See Attachment 4

The cost estimates for each of the M&V activities are listed in Table 2-2.

TABLE 2-2: PROJECT M&V COSTS FOR LENGTH OF CONTRACT

Task	Hourly Cost	Estimated Hours	Total Cost
Measure run-time of lighting	\$100	40	\$4,000
Post-installation report	\$65	10	\$650
First year cost			\$4,650
Annual site visits	\$65	8	\$520
Savings analysis	\$100	8	\$800
Annual Savings Report	\$100	10	\$1,000
Annual M&V Cost			\$1,320

3 CHILLER REPLACEMENT EXAMPLE PROJECT – FEMP OPTION B, METHOD CH-B-02

Description of Energy Conservation Measure

The Piscataway Federal Center is cooled by a central chilled water plant with a 400-ton centrifugal chiller that is 20 years old and requires replacement. The existing chiller has a nominal efficiency of 0.85 kW/ton, which is significantly poorer in comparison with efficiencies of currently available centrifugal chillers. The proposed chiller will have a nominal ARI rating of 0.52 kW/ton.

As part this ESPC project, the existing chiller will be replaced with a new, high efficiency unit. Energy savings for this measure will result from the reduction of chiller demand to provide the same cooling as in the baseline case. Note that cooling savings will only be claimed during actual operating hours of the new chiller.

Annual energy savings from the installation of the new chiller are estimated 235,374 kWh and 106 kW peak demand. Annual cost savings are expected to be \$22,561.

M&V Approach

FEMP Option B, Method CH-B-02 will be used to measure and verify the energy savings from this retrofit. This method requires metering of chiller electric and load variables in both the baseline and post-installation period. Baseline metering was performed over a short-term period, and continuous metering will be done in the post-installation period.

The purpose of collecting baseline chiller data was to develop a model of the existing chiller's performance. This model will enable the prediction of chiller demand from load data (details are explained in M&V Activities section). Approximately one month (August 13 to September 17 1999) of baseline metering was conducted, with enough data points collected to successfully build the performance model.

In the post-installation period, chiller demand and load data will be collected continuously. The load data will be used to determine the equivalent baseline chiller demand for the same interval. Savings will be determined from the difference in the calculated baseline chiller demand, and the measured post-installation chiller demand.

It is appropriate to use Option B for this project for several reasons. There is a significant uncertainty in what the actual operation hours of the new chiller will be, data collection will be less costly with the use of EMCS data, and analysis of the collected data will provide a continuous performance check on the new chiller.

Assumptions

This M&V plan is based on the following assumptions:

- No other changes are planned to the condenser pumps, chilled water pumps or the cooling tower.
- One month of monitoring of chiller demand and load variables was adequate to develop an accurate model of the existing chiller performance.

- The office building plans no major building projects, such as building additions, or changes which would significantly alter the current building occupancy rate, schedule, or other internal cooling loads.

M&V Activities

ABC Engineering will conduct all M&V activities associated with the chiller ECM unless otherwise indicated. The measurement and verification (M&V) activities that will be performed are outlined for both the baseline and post-installation periods below.

Baseline Period

- A data collection of the existing chiller's demand, entering and leaving chilled water temperatures, and entering condenser water temperature occurred during August and September 1999. The data was collected in 15-minute intervals using an Elite 6-channel data recorder⁸. In order to collect data over a full range of operating conditions (chilled and condenser water temperatures, chiller demand) expected in the post-installation period, the condenser and chilled water temperatures were reset manually. Chilled water flow were measured with an in-line flow meter installed in each loop.
- The data was analyzed and an appropriate model of chiller performance was developed, and is detailed in the following section.

Post-Installation Period

- After the new chiller has been installed and commissioned, ABC Engineering and Federal Center representatives will conduct a post-installation inspection to verify that the chiller installed is consistent with what was proposed. ABC Engineering will provide a post-installation report detailing actual equipment installed, and include manufacturer's specifications and operating procedures, and commissioning reports (including chilled water and condenser water flow).
- Post-installation monitoring of chiller demand and load variables (entering and leaving chilled water temperatures, condenser water temperature) will be conducted for the entire contract period. This monitoring will be accomplished using the new building energy management and control system (EMCS). The EMCS will log and time-stamp the data at 15-minute intervals, saving the data weekly to disk. ABC Engineering will remotely download this data on a bi-monthly basis for back up and quality control. In the event that there is a significant gap in the data due to a sensor or other failure, the process to replace the missing data with interpolated or averaged data will be clearly documented.
- Using the monitored post-installation data, collected as described above, the baseline energy use will be computed using the model developed from the monitored baseline data.
- The new chiller's performance will be compared to the manufacturers' rated performance annually to ensure that the chiller is operating as expected. Some chiller performance degradation is expected over the course of the delivery order contract (5 years), which has been considered in determining the expected energy savings and the annual contract payments. If substantial equipment degradation occurs, the Agency will be responsible for taking the necessary maintenance actions to restore the chiller performance.

⁸ See Attachment 4.

- In the event of an unseasonably mild summer or change to the facility that decreases cooling load, the savings claimed will be based on a minimum cooling load of six hundred thousand ton-hours.

Calculations and Adjustments

The following additional notations are applicable to the equations used in this section.

CHWF	Chilled water flow in gallons per minute (GPM)
ECWT	Entering chilled water temperature (return temperature, °F)
LCWT, CHWT	Leaving chilled water temperature (supply temperature, °F)
CWT	Condenser water temperature (°F)
PLR	Part Load Ratio
500	Conversion from GPM to pounds per hour
1	Btu per pound-degree Fahrenheit
12,000	Conversion from BTUH to tons
CAP _{nom}	Nominal or full-load capacity of chiller
kW _{nom}	Nominal or full load chiller demand

Baseline Period

The monitored data collected during the baseline period was used to develop the following model of the existing chiller. The model is consistent with the form of chiller models specified in ASHRAE 90.1, which includes a set of bi-quadratic and quadratic equations, shown below.

$$CAP_t = CAP_{nom}[a + b(CHWT) + c(CHWT)^2 + d(CWT) + e(CWT)^2 + f(CHWT)(CWT)]$$

$$Temp_{adj} = g + h(CHWT) + i(CHWT)^2 + j(CWT) + k(CWT)^2 + l(CHWT)(CWT)$$

$$PLR_{adj} = m + n(PLR_t) + o(PLR_t)^2$$

From the metered data, the coefficients a through o were determined as listed in the table below:

CAP _t	a	b	c	d	e	f
	1.937313	-0.047633	-0.000345	-0.002434	-0.000425	0.001339
Temp _{adj}	g	h	i	j	k	l
	3.871122	-0.126035	0.000308	-0.005309	-0.000375	0.001389
PLR _{adj}	m	n	o			
	0.326267	-0.049116	0.722848			

In addition, the chiller load and current part-load ratio are calculated by the following equations:

$$TONS_t = (CHWF)(500)(ECWT - LCWT)(1) / (12,000)$$

$$PLR_t = TONS_t / CAP_t$$

Chiller electric demand is calculated by:

$$kW_t = (kW_{nom})(PLR_{adj})(Temp_{adj})$$

The nominal kW is the nominal rating multiplied by the nominal capacity: $0.85 \times 400 = 340$ kW.

The procedure for calculating the baseline chiller performance is outlined below. All calculations will be made in a spreadsheet using data for periods when the chiller is operating during the performance period.

1. Calculate the current load on the chiller ($TONS_t$),
2. Calculate the current capacity of the chiller (CAP_t),
3. Calculate the current part-load ratio of the chiller (PLR_t),
4. Calculate the part-load-ratio adjustment (PLR_{adj}),
5. Calculate the temperature adjustment ($Temp_{adj}$),
6. Calculate the baseline chiller demand (kW_t),

Post-Installation Period

After the new chiller is installed, the chiller's post-installation electricity use will be measured, along with the chiller's load data (entering and leaving chilled water temperature, condenser water temperature, chilled water flow-rate).

The baseline electrical use will be estimated based on the model described in the previous section (steps 1 through 6).

The energy savings will be calculated using Equation 3-1 and Equation 3-2 below.

EQUATION 3-1:

$$\begin{aligned} \text{Energy Savings (kWh)} &= \sum_t (kWh_{t, \text{baseline}} - kWh_{t, \text{measured, post}}) \\ &= 0.25 \times \sum_t (kW_{t, \text{baseline}} - kW_{t, \text{measured post}}) \end{aligned}$$

Where:

$kW_{t, \text{baseline}}$ is the demand that the baseline chiller would have used under the load conditions encountered for interval t in the post-installation period, and

$kW_{t, \text{measured, post}}$ is the measured demand of the new chiller during interval t .

EQUATION 3-2

$$\text{Monthly Demand Savings (kW)} = \text{MIN}(kW_{t, \text{baseline}}) - \text{COINCIDENT}(kW_{t, \text{post}})$$

Where:

$\text{MIN}(kW_{t, \text{baseline}})$ is the minimum of all baseline chiller demand predicted for each 15-minute interval in the peak period (between noon and 6 PM weekdays, May through October) during the current month using the model developed for the baseline chiller.

$\text{COINCIDENT}(kW_{t, \text{post}})$ is the measured demand of the new chiller during the interval when the predicted baseline chiller demand was at its minimum value.

Annual cost savings will be calculated using Equation 3-3.

EQUATION 3-3:

$$\text{Annual Cost Savings} = \text{Energy Savings (kWh)} * \text{Rate}_{\text{kWh}} + \sum_{\text{month}} (\text{Monthly Demand Savings} * \text{Rate}_{\text{kW}})$$

Where the rates are \$0.0525 per kWh, and \$8.025 per kW.

Metering Plan

In the baseline period, ABC installed an Elite 6-channel data recorder to capture the required data on the baseline chiller. In the post-installation period, the same variables will be monitored through the newly installed EMCS. One-minute data will be averaged every 15 minutes and recorded. Parameters to be monitored are the chiller demand, chilled water flow, condenser water return temperature, chilled water supply temperature, and chilled water return temperatures. All sensor costs in the post-installation period are included in the cost of the EMCS.

Baseline Period.

- All parameters will be monitored with an Elite 6-channel data recorder. Modules are available to measure true AC power, temperature, and flow.
- Chilled and condenser water temperatures will be measured using platinum RTD probes. The chilled water sensors will be from a matched set for the highest accuracy (0.5%).
- Chilled water flow will be measured with a paddle-wheel sensor that has an accuracy of 10%.
- The true-power AC module measures three-phase voltage and current. It provides a single analog signal proportional to true power with 2% accuracy.

Post-Installation Period

Chiller demand: The chiller demand will be monitored using solid core current transducers and voltage leads connected to each leg of the chiller's 3 – phase circuit. All leads will be installed at the time of EMCS installation. These transducers will be installed on breakers 1, 3 and 5 (the A, B and C phases) of switch-gear SW-1. Calibration of these sensors will be accomplished using an ACME true RMS kW meter. Calibration of this parameter will be carried out once per year.

Chilled water flow: Chilled water flow will also be monitored through the EMCS. At the time of chiller installation, an ACME inline flow meter will be installed in the chilled water loop. The flow meter is specified by the manufacturer to have an accuracy of $\pm 10\%$. The chilled water flow will be verified bi-monthly by downloading and checking data to identify sensors that have fallen out of calibration or to determine whether chiller performance has been degraded.

Condenser and chilled water temperatures: Water temperature sensors will be the insertion type, installed in new thermo-wells for both the condenser and chilled water temperatures. The sensors used will be ACME 2-wire, 1,000 OHM platinum RTDs paired with a 4-20mA transmitter. The combined unit(s) will have an operating range of 20-120°F with an accuracy of $\pm 0.50^\circ\text{F}$. A field check of calibration will be conducted using the analog thermometers installed in the supply and condenser water lines.

In addition to the calibration and testing procedures outlined above, all components will be tested and evaluated once each contract year. Also, the EMCS will continuously monitor the calculated kW/ton of the new chiller and issue an alarm when this value moves outside the expected range (0.40 - 1.10 kW/ton).

The data will be collected using quality control procedures for checking the measurements for reasonableness. Any and all missing intervals will be replaced either by interpolation or use of average values. Such data will be described in annual reports.

Project Budget

The following table estimates the cost of the M&V activities for this ECM.

TABLE 3-1: PROJECT M&V COSTS

Tasks	Rate	Hours	Total Cost
Collect baseline data	\$65	40	\$2,600
Baseline data analysis	\$100	24	\$2,400
Post-installation report	\$65	10	\$650
First year cost			\$5,650
Post-installation data analysis set-up	\$100	8	\$800
Bi-monthly downloads & data validation, troubleshooting	\$65	18	\$1,170
Site visit	\$65	8	\$520
Savings analysis	\$100	24	\$2,400
Annual report	\$100	10	\$1,000
Annual M&V cost			\$5,890

4 ENERGY MANAGEMENT CONTROL SYSTEM (EMCS) INSTALLATION - OPTION B, METHOD GVL-B-01

Description of Energy Conservation Measure

A new energy management and control system (EMCS) will be installed in the Federal Center to provide enhanced control of the facility's HVAC systems. This system will provide energy and cost savings by providing time of day control for the chiller, water circulation pumps and air-handler fans.

Currently, the HVAC fans and pumps (motors 25 to 75 HP) operate at constant speed under manual control. The fan motors operate continuously, and the chiller and pump motors run for longer than necessary.

The control system will use an "optimum start" sequence to determine the start-up time for this equipment. This sequence will evaluate indoor and outdoor conditions and start the equipment accordingly so that proper set-points are reached prior to occupancy. The winter set-point (October – April) will be 68 °F, and the summer set-point (May – September) will be 72 °F.

The new control system will start and stop the equipment as needed, thereby reducing operating hours, and provide savings in the form of reduced kilowatt-hour consumption. Demand savings will not be realized for this measure, because the reduced operation hours will take place at night and not during daytime peak periods.

Note that the chiller savings claimed for this measure results from reducing chiller operation at night. The savings claimed from installation of the new chiller (and detailed in the previous M&V plan for the chiller ECM) results from reduced demand during operation of the chiller. Care was taken to ensure that no double-counting of savings has been included.

Annual energy savings from this ECM are projected to be 899,252 kWh, with cost savings of \$47,211. Additional benefits to be realized by the Agency include: improved control of HVAC equipment and reduced operation expenses because of EMCS monitoring of equipment status.

M&V Approach

The measurement and verification plan for the EMCS installation will follow **FEMP Option B, Method GVL-B-01**, generic variable load project with continuous metering. The EMCS system will be used to record the actual run time of the equipment.

Option B was chosen for this measure because of the concern that post-installation motor operation hours may not turn out as estimated. In addition, Option B was selected because the installation of the new control system readily lends itself to ongoing measurement. The control system can track the actual run times of equipment with great accuracy and very little added cost.

Assumptions

The following assumptions are employed for this M&V plan:

- In the absence of this project, the pump and fan performance would remain constant (and not degrade) at the levels measured during the detailed energy survey. This is a conservative

estimate in that should motor demand levels increase, the overall affect on baseline energy consumption would be to increase, thus increasing the savings estimated for this project. The chiller performance will be based on the manufacture's performance specifications for the new chiller at the average off-hour load and run-times calculated from the chiller baseline measurements.

- In the absence of this project, the operation schedule of the chiller, pump and fan motors would remain the same and baseline operation hours would remain constant. Facility staff indicated that the operation schedule had not changed for the previous 5 years.
- The occupied hours of the facility are assumed to remain unchanged for the duration of the project, and are Monday – Friday from 7:00 AM to 7:00 PM, and on Saturday from 9:00 AM to 3:00 PM.

M&V Activities

The measurement and verification (M&V) activities that will be performed are outlined for both the baseline and post-installation periods below.

Baseline Period

The current annual operating hours that were reported by the facility staff are shown in Table 4-1. Cooling equipment (chiller and water pumps) operate continuously from May through September. The hot water pump operates continuously from October through April. The air handler fans operate continuously year-round. There is some operation of the cooling system and heating system during off-seasons. Because their operation is not easily characterized during the off-season, no estimation of savings was made for these time periods, and no M&V activities are described either. ABC Engineering realizes that it is forgoing some savings that could otherwise be claimed, but believes the M&V effort to characterize the operating hours are too expensive to justify.

TABLE 4-1: EQUIPMENT BASELINE OPERATING HOURS

Equipment	Operating Period	Annual Hours
Chiller	Always on	8,760
AHU-1 supply fan	Always on	8,760
EX-1 exhaust fan	Always on	8,760
CHWP-1 chilled water supply pump	On May – September	3,672
CWP-1 condenser water pump	On May – September	3,672
HWP-1 hot water supply pump	On October – April	5,088

Motor kW demand is assumed to remain constant for the duration of the contract. The nameplate data of each motor was recorded, and the power draw from each was measured on May 1, 2000 by ABC staff, in the presence of Mr. Handy, Federal Center Facility Manager. These values are shown in Table 4-2 below.

TABLE 4-2: EQUIPMENT NAMEPLATE DATA AND MEASURED POWER DRAW

Equipment	Nameplate Data (HP)	Nominal RPM	Nominal Voltage	Measured Power Draw (kW)
AHU-1 supply fan	75	1800	480	68.3
EX-1 exhaust fan	50	1800	480	48.7
CHWP-1 chilled water supply pump	25	1800	480	27.4
CWP-1 condenser water pump	25	1800	480	27.4
HWP-1 hot water supply pump	25	1800	480	26.7

The chiller off-time resulting from the EMCS is considered separately, since although the equipment is always enabled, it does not run continuously, nor at a constant load. The off-hour savings for the chiller due to EMCS will be based on the average measured load during unoccupied hours during chiller baseline measurements, and the predicted performance of the new chiller, as shown in Table 4-3.

TABLE 4-3: AFTER HOURS CHILLER OPERATION

Maximum Chiller Tons	Average After-hours tons	kW/Ton New Chiller	kW New Chiller	EMCS Resulting Off-Hours
400	101	1.00	101	3,950

Post-Installation Period

The points in the new EMCS system to be monitored for use in savings calculation are listed in Table 4-4. All of these points will be “trended” meaning that there will be a time-of-day stamp associated with each point. From this information, the total operating hours for the year will be calculated. Temperature data will be collected and analyzed to ensure that the operation of the control system is as intended. A complete listing of the EMCS system parameters will be provided in the operations manual submitted as part of the post-installation report.

TABLE 4-4: EMCS CONTROL POINTS FOR SAVINGS CALCULATIONS

Equipment	Type of Point
Chiller compressor motor	Status
AHU-1 supply fan	Status
EX-1 exhaust fan	Status
CHWP-1 chilled water supply pump	Status
CWP-1 condenser water pump	Status
HWP-1 hot water supply pump	Status
Indoor air temperature	Analog temperature sensor
Outside air temperature	Analog temperature sensor
Outside humidity sensor	Analog humidity sensor

The EMCS system will be set up to automatically write the recorded run-time data to the dedicated control computer's hard-drive each day at midnight. Every-other month ABC Engineering staff will remotely download that data for analysis and back-up purposes. The data will be reviewed at that time to ensure the control system is operating properly.

During the first quarter of each year (January to March) a site visit to the Federal Center will be conducted by ABC Engineering personnel. Activities to be conducted during this site visit include: replacement of all batteries in control panels; verification of proper equipment operation; measurement of power draw of the equipment listed in Table 4-2 to ensure that the equipment demand has not changed.

Calculations and Adjustments

The run-time data recorded by the ECMS equipment will be analyzed and summarized after it receipt on a bi-monthly basis. For each motor, during its operation period (Table 4-1), the total number of operating hours will be determined by the summing the status data collected for each motor, and multiplying by the data interval (15 minute).

Annually, Equation 4-1 and Equation 4-2 will be used to calculate the energy savings resulting from the EMCS installation for each piece of equipment listed in Table 4-1.

EQUATION 4-1:

$$\text{Annual kWh}_{\text{saved motor } i} = \text{kW}_{\text{baseline motor } i} \times (\text{Op. Hours}_{\text{baseline motor } i} - \text{Op. Hours}_{\text{measured motor } i})$$

EQUATION 4-2:

$$\text{Total Annual kWh}_{\text{saved}} = \text{Annual kWh}_{\text{saved chiller}} + \text{Annual kWh}_{\text{saved AHU1}} + \text{Annual kWh}_{\text{saved EX-1}} + \text{Annual kWh}_{\text{saved CHWP-1}} + \text{Annual kWh}_{\text{saved CWP-1}} + \text{Annual kWh}_{\text{saved HWP-1}}$$

Although not anticipated, any significant increase in occupied hours for the facility would diminish the savings from this project. This delivery order was developed with the understanding that the

current occupancy rate will remain the same as in the baseline period. Should the occupancy rate increase, the savings will decrease. ABC Engineering has no control over occupancy schedules for the Federal Center. However, ABC is responsible for EMCS performance.

Normally, the EMCS should start the heating and cooling equipment approximately one hour before occupancy, and shut systems down up to one hour after occupancy. This increases operation hours to two hours beyond the daily operation schedule.

To account for the possibility that occupancy schedules are increased by the agency, a maximum will be set for the annual operating hours that will be used in Equation 4-1 for operating hours_{measured}. The maximums for each piece of equipment are based on baseline scheduled building occupancy hours plus 6 hours per day. These maximum allowable hours are listed in Table 4-5.

TABLE 4-5: MAXIMUM ALLOWABLE POST-INSTALLATION OPERATING HOURS

Equipment	Maximum Annual Post-Installation Operating Hours
Chiller compressor motor	4,810
AHU-1 supply fan	5,616
EX-1 exhaust fan	5,616
CHWP-1 chilled water supply pump	2,370
CWP-1 condenser water pump	2,370
HWP-1 hot water supply pump	3,270

Metering Plan

The equipment that was used for taking the baseline power measurements will be used during the annual site visit to verify equipment performance. The meter to be used is a digital multi-meter, ACME model 40, which is calibrated by the manufacturer on a semi-annual basis. The meter has an accuracy of $\pm 0.5\%$. The meter specifications are included in Attachment 2.

The temperature sensors that will be used to determine the set point will be Elite Industries thermistor sensors. These sensors are rated at ± 1 °F accuracy. Cut sheets are included in Attachment 2.

Ongoing quality assurance procedures for the metered run times of equipment include a bi-monthly review of the data to see if it is reasonable and corresponds to anticipated values. Raw data files will be stored separately and made available to the Agency upon request. In the case that some data are missing, a check for a valid reason for missing data will be made. If the data is truly missing, then operating hours for the period with missing data will be derived from data from a similar period. Sources of data used to make up for missing data will be clearly identified and will be described in the annual reports.

Project Budget

The cost estimates for each of the M&V activities for this ECM are listed in the following table.

TABLE 4-6: PROJECT M&V COSTS FOR LENGTH OF CONTRACT

Task	Hourly Cost	Estimated Hours	Total Cost
Develop and program EMCS for data collection	\$100	6	\$600
Post-Installation Report	\$65	8	\$520
First year cost			\$1,120
Bi-monthly downloads, data validation, troubleshooting	\$65	24	\$1,170
Annual site visit	\$65	8	\$520
Savings analysis	\$100	8	\$800
Annual Report	\$100	8	\$800
Annual M&V cost			\$3,290

ATTACHMENT 1. FEDERAL CENTER LIGHTING INVENTORY

Lighting Fixture Survey

Table LE1

Site Federal Center
Name:

Date of 5/1/00
Table:
Table Thomas Edison
Complete
d By:

Pre-
Installation

Space	Circuit	Usage	EXISTING LIGHTING EQUIPMENT					PROPOSED LIGHTING EQUIPMENT					Control	Space Conditioned ?	
			Equip.	No. of	No. of Non - Operating	kW Per	kW Per	Equipment	No. of	kW Per	kW Per				
ID	ID	Area Type	Type	Fixtures	Fixtures	Fixture	Space	Type	Fixtures	Fixture	Space	Device	(Yes/No)	Notes	
10-1	1	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes		
10-2	2	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes		
10-3	3	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes		
10-4	4	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes		
10-5	5	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes		
10-6	6	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes		
10-7	7	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes		
10-8	8	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes		
10-9	9	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes		
10-10	10	Closed Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes		
10-11	11	Storage, comp. closets	F44ES	5	0	0.144	0.720	F44ILL-R	5	0.102	0.510	switch	yes		
10-11a	12	Storage, comp. closets	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes		
10-12	13	Storage, comp. closets	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	tele/elec	
10-14	14	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes		
10-15	15	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes		
10-16	16	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes		
10-17	17	Common Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes		
10-18	18	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	copy/fax	
10-19	19	Conference Rooms	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes		
10-20	20	Common Office Areas	F46ES	2	0	0.216	0.432	F44ILL-R	2	0.102	0.204	switch	yes		
10-21	21	24 Hour - Misc	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	breaker	yes		
10-21a	22	24 Hour - Exit	EI15/2	4	0	0.030	0.120	ELED2/2	4	0.009	0.036	breaker	yes		
10-21c	23	Common Office Areas	F44ES	21	0	0.144	3.024	F44ILL-R	21	0.102	2.142	switch	yes		
10-22	24	Common Office Areas	I75/1	7	0	0.075	0.525	CF13/1-	7	0.013	0.091	switch	yes		

								scrw						
10-22a	25	24 Hour - Exit	EI15/2	4	0	0.030	0.120	ELED2/2	4	0.009	0.036	breaker	yes	hall and recption
10-22b	26	24 Hour - Misc	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	breaker	yes	hall and recption
10-22c	27	Common Office Areas	F44ES	9	0	0.144	1.296	F44ILL-R	9	0.102	0.918	switch	yes	hall and recption
10-23	28	Common Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	kitchen
10-24	29	Closed Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
10-25	30	Closed Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	vacant
10-26	31	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
10-27	32	Conference Rooms	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
10-28	33	Common Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
10-29	34	Closed Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
10-30	35	Closed Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
10-31	36	Common Office Areas	F44ES	8	0	0.144	1.152	F44ILL-R	8	0.102	0.816	switch	yes	
10-32	37	Storage, comp. closets	I150/1	1	0	0.150	0.150	CF13/1- scrw	1	0.013	0.013	switch	yes	closet
10-33	38	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
10-34	39	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
10-35	40	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
10-36	41	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
10-37	42	Common Office Areas	F44ES	12	0	0.144	1.728	F44ILL-R	12	0.102	1.224	switch	yes	
10-37a	43	24 Hour - Exit	EI15/2	2	0	0.030	0.060	ELED2/2	2	0.009	0.018	breaker	yes	
10-38	44	Halls and Common areas	F41ES	2	0	0.048	0.096	F41ILL	2	0.031	0.062	switch	yes	
10-38	45	Halls and Common areas	F41ES	2	0	0.048	0.096	F41ILL/T2	2	0.030	0.060	switch	yes	no chase nipple needed
10-39	46	Halls and Common areas	F41ES	3	0	0.048	0.144	F41ILL	3	0.031	0.093	switch	yes	laddies room
10-40	47	Halls and Common areas	CF23/1- scrw	2	0	0.023	0.046	CF13/1- scrw	2	0.013	0.026	switch	yes	
10-40a	48	24 Hour - Exit	EI15/2	3	0	0.030	0.090	ELED2/2	3	0.009	0.027	breaker	yes	
10-41	49	Storage, comp. closets	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	storage/ southwestern bell
10-42	50	Storage, comp. closets	I75/1	1	0	0.075	0.075	CF23/1- scrw	1	0.023	0.023	switch	yes	tele. rm.
10-43	51	Storage, comp. closets	I75/1	1	0	0.075	0.075	CF23/1- scrw	1	0.023	0.023	switch	yes	elec. Rm.
10-44	52	Storage, comp. closets	F42ES	2	0	0.082	0.164	F42ILL-R	2	0.052	0.104	switch	yes	mech. Rm.
10-45	53	Storage, comp. closets	I75/1	1	0	0.075	0.075	CF23/1-	1	0.023	0.023	switch	yes	jan. closet

								scrw						
9-1	54	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
9-2	55	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
9-3	56	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
9-4	57	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	copy/fax
9-5	58	Common Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
9-6	59	Common Office Areas	F44ES	9	0	0.144	1.296	F44ILL-R	9	0.102	0.918	switch	yes	
9-7	60	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
9-8	61	Closed Office Areas	F44ES	5	0	0.144	0.720	F44ILL-R	5	0.102	0.510	switch	yes	
9-9	62	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
9-10	63	Common Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
9-10a	64	Common Office Areas	I150/1	3	0	0.150	0.450	CF13/1 - scrw	3	0.013	0.039	dimmer	yes	
9-11	65	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
9-12	66	Closed Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
9-13	67	Storage, comp. closets	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	closet
9-14	68	Common Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	kitchen
9-15	69	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
9-16	70	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
9-17	71	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
9-17	72	Closed Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
9-18	73	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
9-18a	74	Closed Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
9-19	75	Common Office Areas	F44ES	10	0	0.144	1.440	F44ILL-R	10	0.102	1.020	switch	yes	
9-20	76	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
9-21	77	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
9-22	78	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
9-22a	79	Closed Office Areas	I75/1	2	0	0.075	0.150	CF13/1 - scrw	2	0.013	0.026	switch	yes	
9-23	80	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
9-24	81	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
9-25	82	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
9-26	83	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
9-27	84	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
9-28	85	Common Office Areas	F44ES	6	0	0.144	0.864	F44ILL-R	6	0.102	0.612	switch	yes	
9-29	86	Storage, comp. closets	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	closet
9-30	87	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
9-31	88	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
9-31a	89	Storage, comp. closets	I100/1	4	0	0.100	0.400	CF13/1 - scrw	4	0.013	0.052	dimmer	yes	
9-32	90	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	

9-33	91	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	nursery
9-34	92	Halls and Common areas	F41ES	3	0	0.048	0.144	F41ILL	3	0.031	0.093	breaker	yes	restroom
9-35	93	Halls and Common areas	F41ES	2	0	0.048	0.096	F41ILL	2	0.031	0.062	breaker	yes	restroom
9-35	94	Halls and Common areas	F41ES	2	0	0.048	0.096	F41ILL/T2	2	0.030	0.060	breaker	yes	restroom
9-36	95	Halls and Common areas	CF23/1-scrw	3	0	0.023	0.069	CF13/1-scrw	3	0.013	0.039	breaker	yes	
9-36a	96	24 Hour - Exit	EI15/2	3	0	0.030	0.090	ELED2/2	3	0.009	0.027	breaker	yes	lobby and hall
8-1	97	Common Office Areas	F44ES	5	0	0.144	0.720	F44ILL-R	5	0.102	0.510	switch	yes	managements office
8-2	98	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	managements office
8-3	99	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	managements office
8-4	100	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	managements office
8-5	101	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	managements office
8-6	102	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	managements office
8-7	103	Common Office Areas	F44ES	20	0	0.144	2.880	F44ILL-R	20	0.102	2.040	switch	yes	under construction/ vacant
8-8	104	Common Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	under construction/ vacant
8-9	105	Common Office Areas	F44ES	12	0	0.144	1.728	F44ILL-R	12	0.102	1.224	switch	yes	under construction/ vacant
8-10	106	Halls and Common areas	CF23/1-scrw	1	0	0.023	0.023	CF13/1-scrw	1	0.013	0.013	breaker	yes	
8-10a	107	24 Hour - Exit	EI15/2	1	0	0.030	0.030	ELED2/2	1	0.009	0.009	breaker	yes	
8-11	108	Common Office Areas	F44ES	6	0	0.144	0.864	F44ILL-R	6	0.102	0.612	switch	yes	
8-12	109	Storage, comp. closets	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	comp. closet
8-13	110	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
8-14	111	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
8-15	112	Closed Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
8-16	113	Closed Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
8-17	114	Closed Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
8-18	115	Closed Office Areas	F44ES	6	0	0.144	0.864	F44ILL-R	6	0.102	0.612	switch	yes	
8-19	116	Common Office Areas	F44ES	11	0	0.144	1.584	F44ILL-R	11	0.102	1.122	switch	yes	
8-19a	117	Common Office Areas	F44ES	15	0	0.144	2.160	F44ILL-R	15	0.102	1.530	switch	yes	
8-20	118	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	under construction
8-21	119	Common Office Areas	F44ES	6	0	0.144	0.864	F44ILL-R	6	0.102	0.612	switch	yes	under construction
8-22	120	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	under construction
8-23	121	Storage, comp. closets	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	under construction
8-24	122	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	under construction
8-25	123	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	under construction
8-26	124	Common Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	under construction
8-27	125	Halls and Common areas	F41ES	3	0	0.048	0.144	F41ILL	3	0.031	0.093	switch	yes	

8-28	126	Halls and Common areas	F41ES	2	0	0.048	0.096	F41ILL	2	0.031	0.062	breaker	yes	
8-28	127	Halls and Common areas	F41ES	2	0	0.048	0.096	F41LL/T2	2	0.030	0.060	breaker	yes	
8-29	128	Common Office Areas	I75/1	8	0	0.075	0.600	CF13/1-scrw	8	0.013	0.104	switch	yes	
8-30	129	Common Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
8-30a	130	Common Office Areas	I75/1	1	0	0.075	0.075	CF13/1-scrw	1	0.013	0.013	switch	yes	
8-31	131	Common Office Areas	I75/1	6	0	0.075	0.450	CF13/1-scrw	6	0.013	0.078	switch	yes	
8-31a	132	Common Office Areas	F44ES	11	0	0.144	1.584	F44ILL-R	11	0.102	1.122	switch	yes	
8-31b	133	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
8-32	134	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
8-33	135	Storage, comp. closets	I50/1	1	0	0.050	0.050	CF23/1-scrw	1	0.023	0.023	switch	yes	1 pc
8-34	136	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
8-35	137	Common Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
8-36	138	Common Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
8-37	139	Storage, comp. closets	I75/1	1	0	0.075	0.075	CF23/1-scrw	1	0.023	0.023	switch	yes	elec. Rm
8-38	140	Storage, comp. closets	F42ES	2	0	0.082	0.164	F42ILL-R	2	0.052	0.104	switch	yes	mech. Rm
8-39	141	Storage, comp. closets	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
8-40	142	Halls and Common areas	F41ES	3	0	0.048	0.144	F41ILL	3	0.031	0.093	switch	yes	
8-41	143	Halls and Common areas	F41ES	2	0	0.048	0.096	F41ILL	2	0.031	0.062	breaker	yes	
8-41	144	Halls and Common areas	F41ES	2	0	0.048	0.096	F41LL/T2	2	0.030	0.060	breaker	yes	
8-42	145	Storage, comp. closets	I75/1	1	0	0.075	0.075	CF23/1-scrw	1	0.023	0.023	switch	yes	jan. closet
8-43	146	Storage, comp. closets	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
8-44	147	Storage, comp. closets	I75/1	1	0	0.075	0.075	CF23/1-scrw	1	0.023	0.023	switch	yes	tele. Rm
7-1	148	Closed Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
7-2	149	Conference Rooms	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
7-3	150	Conference Rooms	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
7-4	151	Common Office Areas	F44ES	5	0	0.144	0.720	F44ILL-R	5	0.102	0.510	switch	yes	
7-5	152	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
7-6	153	Common Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	copy rm.
7-7	154	Common Office Areas	F44ES	6	0	0.144	0.864	F44ILL-R	6	0.102	0.612	switch	yes	comp/printer rm
7-8	155	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	file rm

7-9	156	Common Office Areas	F44ES	8	0	0.144	1.152	F44ILL-R	8	0.102	0.816	switch	yes	
7-9a	157	Common Office Areas	F44ES	16	0	0.144	2.304	F44ILL-R	16	0.102	1.632	switch	yes	
7-9b	158	Common Office Areas	F44ES	12	0	0.144	1.728	F44ILL-R	12	0.102	1.224	switch	yes	
7-10	159	Common Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
7-11	160	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
7-12	161	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
7-13	162	Common Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
7-14	163	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
7-15	164	Common Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
7-16	165	Common Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
7-17	166	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
7-18	167	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
7-19	168	Halls and Common areas	F41ES	3	0	0.048	0.144	F41ILL	3	0.031	0.093	switch	yes	restroom
7-20	169	Halls and Common areas	F41ES	2	0	0.048	0.096	F41ILL	2	0.031	0.062	switch	yes	restroom
7-20	170	Halls and Common areas	F41ES	2	0	0.048	0.096	F41ILL/T2	2	0.030	0.060	switch	yes	restroom
7-20	171	Halls and Common areas	I150/1	2	0	0.150	0.300	CF13/1-scrw	2	0.013	0.026	switch	yes	
7-21	172	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
7-22	173	Common Office Areas	F44ES	5	0	0.144	0.720	F44ILL-R	5	0.102	0.510	switch	yes	
7-22	174	Common Office Areas	F24SS	1	0	0.112	0.112	F22LL-R	1	0.028	0.028	switch	yes	
7-23	175	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
7-24	176	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
7-25	177	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
7-26	178	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
7-27	179	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
7-28	180	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
7-29	181	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
7-30	182	Closed Office Areas	F44ES	6	0	0.144	0.864	F44ILL-R	6	0.102	0.612	switch	yes	
7-31	183	Common Office Areas	F44ES	8	0	0.144	1.152	F44ILL-R	8	0.102	0.816	switch	yes	
7-32	184	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
7-33	185	Storage, comp. closets	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	closet
7-34	186	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
7-35	187	Common Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
7-36	188	Closed Office Areas	F44ES	5	0	0.144	0.720	F44ILL-R	5	0.102	0.510	switch	yes	
7-36a	189	Closed Office Areas	I75/1	2	0	0.075	0.150	CF13/1-scrw	2	0.013	0.026	switch	yes	
7-37	190	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
7-38	191	Common Office Areas	F44ES	6	0	0.144	0.864	F44ILL-R	6	0.102	0.612	switch	yes	

7-39	192	Common Office Areas	F44ES	7	0	0.144	1.008	F44ILL-R	7	0.102	0.714	switch	yes	
7-40	193	Halls and Common areas	CF23/1-scrw	2	0	0.023	0.046	CF13/1-scrw	2	0.013	0.026	breaker	yes	
7-40a	194	24 Hour - Exit	EI15/2	1	0	0.030	0.030	ELED2/2	1	0.009	0.009	breaker	yes	
7-41	195	Storage, comp. closets	I75/1	1	0	0.075	0.075	CF23/1-scrw	1	0.023	0.023	switch	yes	tele tm.
7-42	196	Storage, comp. closets	I75/1	1	0	0.075	0.075	CF23/1-scrw	1	0.023	0.023	switch	yes	elec. Rm
7-43	197	Storage, comp. closets	I75/1	1	0	0.075	0.075	CF23/1-scrw	1	0.023	0.023	switch	yes	closet
6-1	198	Common Office Areas	I75/1	8	0	0.075	0.600	CF13/1-scrw	8	0.013	0.104	switch	yes	
6-1a	199	Common Office Areas	I75/1	3	0	0.075	0.225	CF13/1-scrw	3	0.013	0.039	switch	yes	
6-1b	200	Common Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
6-2	201	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-3	202	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	copy rm.
6-4	203	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-5	204	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-6	205	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-6a	206	Closed Office Areas	I75/1	4	0	0.075	0.300	CF13/1-scrw	4	0.013	0.052	switch	yes	
6-7	207	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-7a	208	Closed Office Areas	I75/1	2	0	0.075	0.150	CF13/1-scrw	2	0.013	0.026	switch	yes	
6-8	209	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-9	210	Common Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
6-10	211	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-11	212	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-12	213	Storage, comp. closets	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
6-13	214	Halls and Common areas	F41ES	2	0	0.048	0.096	F41ILL	2	0.031	0.062	switch	yes	restroom
6-13	215	Halls and Common areas	F41ES	2	0	0.048	0.096	F41ILL/T2	2	0.030	0.060	switch	yes	restroom
6-14	216	Halls and Common areas	F41ES	3	0	0.048	0.144	F41ILL	3	0.031	0.093	switch	yes	restroom
6-15	217	Halls and Common areas	CF23/1-scrw	1	0	0.023	0.023	CF13/1-scrw	1	0.013	0.013	switch	yes	
6-15a	218	24 Hour - Exit	EI15/2	1	0	0.030	0.030	ELED2/2	1	0.009	0.009	breaker	yes	
6-16	219	Common Office Areas	F44ES	5	0	0.144	0.720	F44ILL-R	5	0.102	0.510	switch	yes	
6-17	220	Closed Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
6-18	221	Common Office Areas	F44ES	6	0	0.144	0.864	F44ILL-R	6	0.102	0.612	switch	yes	

6-18a	222	Common Office Areas	I100/1	6	0	0.100	0.600	CF13/1- scrw	6	0.013	0.078	dimmer	yes	
6-18b	223	Common Office Areas	I100/1	6	0	0.100	0.600	CF13/1- scrw	6	0.013	0.078	dimmer	yes	
6-18c	224	24 Hour - Exit	EI15/2	1	0	0.030	0.030	ELED2/2	1	0.009	0.009	breaker	yes	
6-19	225	Closed Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
6-20	226	Storage, comp. closets	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-21	227	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-22	228	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-23	229	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-24	230	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-25	231	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-26	232	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-27	233	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-28	234	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-29	235	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
6-30	236	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-31	237	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-32	238	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-33	239	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-34	240	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-35	241	Conference Rooms	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
6-36	242	Storage, comp. closets	FU2ES	1	0	0.072	0.072	FU2LL	1	0.060	0.060	switch	yes	
6-37	243	Closed Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
6-38	244	Closed Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
6-39	245	Closed Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
6-40	246	Closed Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
6-41	247	Closed Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
6-42	248	Closed Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
6-43	249	Common Office Areas	F44ES	8	0	0.144	1.152	F44ILL-R	8	0.102	0.816	switch	yes	
6-43a	250	24 Hour - Exit	EI15/2	1	0	0.030	0.030	ELED2/2	1	0.009	0.009	breaker	yes	
6-44	251	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-45	252	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	x-ray
6-45a	253	Common Office Areas	I90/1	2	0	0.090	0.180	CF13/1- scrw	2	0.013	0.026	switch	yes	x-ray
6-45a	254	Common Office Areas	I75/1	1	0	0.075	0.075	CF13/1- scrw	1	0.013	0.013	switch	yes	
6-46	255	Storage, comp. closets	FU2ES	1	0	0.072	0.072	FU2LL	1	0.060	0.060	switch	yes	darkroom
6-47	256	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	kitchen
6-48	257	Common Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
6-49	258	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	

6-50	259	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-51	260	Common Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	bathroom
6-52	261	Common Office Areas	F44ES	33	0	0.144	4.752	F44ILL-R	33	0.102	3.366	switch	yes	
6-52a	262	24 Hour - Exit	EI15/2	5	0	0.030	0.150	ELED2/2	5	0.009	0.045	#VALU E!	yes	
6-53	263	Closed Office Areas	F44ES	6	0	0.144	0.864	F44ILL-R	6	0.102	0.612	switch	yes	
6-54	264	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
6-55	265	Closed Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
6-56	266	Closed Office Areas	F44ES	5	0	0.144	0.720	F44ILL-R	5	0.102	0.510	switch	yes	
6-57	267	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
6-58	268	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
6-59	269	Storage, comp. closets	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
6-60	270	Storage, comp. closets	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
6-61	271	Storage, comp. closets	I75/1	1	0	0.075	0.075	CF23/1 - scrw	1	0.023	0.023	switch	yes	tele rm.
6-62	272	Storage, comp. closets	I75/1	1	0	0.075	0.075	CF23/1 - scrw	1	0.023	0.023	switch	yes	elec. Rm.
6-63	273	Storage, comp. closets	I75/1	1	0	0.075	0.075	CF23/1 - scrw	1	0.023	0.023	switch	yes	closet
6-64	274	Storage, comp. closets	F42ES	2	0	0.082	0.164	F42ILL-R	2	0.052	0.104	switch	yes	
5-1	275	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
5-2	276	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
5-3	277	Common Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	copy
5-4	278	Common Office Areas	F44SS	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
5-5	279	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
5-6	280	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
5-7	281	Closed Office Areas	F44ES	6	0	0.144	0.864	F44ILL-R	6	0.102	0.612	switch	yes	
5-8	282	Storage, comp. closets	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
5-9	283	Conference Rooms	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
5-10	284	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
5-11	285	Closed Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
5-12	286	Closed Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
5-13	287	Common Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
5-14	288	Storage, comp. closets	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
5-15	289	Common Office Areas	F44ES	5	0	0.144	0.720	F44ILL-R	5	0.102	0.510	switch	yes	
5-16	290	Common Office Areas	F44ES	17	0	0.144	2.448	F44ILL-R	17	0.102	1.734	switch	yes	
5-16a	291	24 Hour - Exit	EI15/2	1	0	0.030	0.030	ELED2/2	1	0.009	0.009	breaker	yes	
5-17	292	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
5-18	293	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
5-19	294	Closed Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
5-20	295	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	

5-20a	296	Closed Office Areas	I100/1	4	0	0.100	0.400	CF13/1- scrw	4	0.013	0.052	dimmer	yes	
5-21	297	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
5-22	298	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
5-23	299	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
5-24	300	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
5-25	301	Conference Rooms	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
5-26	302	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
5-27	303	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
5-28	304	Common Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
5-29	305	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
5-30	306	Storage, comp. closets	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	storage
5-31	307	Storage, comp. closets	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	storage
5-32	308	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
5-33	309	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
5-34	310	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
5-35	311	Common Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
5-35a	312	Common Office Areas	F44ES	10	0	0.144	1.440	F44ILL-R	10	0.102	1.020	switch	yes	
5-35b	313	24 Hour - Misc	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	breaker	yes	
5-35c	314	Common Office Areas	F44ES	14	0	0.144	2.016	F44ILL-R	14	0.102	1.428	switch	yes	
5-35d	315	24 Hour - Exit	EI15/2	1	0	0.030	0.030	ELED2/2	1	0.009	0.009	breaker	yes	
5-36	316	Common Office Areas	F44ES	7	0	0.144	1.008	F44ILL-R	7	0.102	0.714	switch	yes	
5-36a	317	24 Hour - Misc	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	breaker	yes	
5-36b	318	24 Hour - Exit	EI15/2	3	0	0.030	0.090	ELED2/2	3	0.009	0.027	breaker	yes	
5-37	319	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
5-38	320	Halls and Common areas	F41ES	2	0	0.048	0.096	F41ILL	2	0.031	0.062	switch	yes	restroom
5-38	321	Halls and Common areas	F41ES	2	0	0.048	0.096	F41ILL/T2	2	0.030	0.060	switch	yes	restroom
5-39	322	Halls and Common areas	F41ES	3	0	0.048	0.144	F41ILL	3	0.031	0.093	switch	yes	restroom
5-40	323	Common Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
5-41	324	Storage, comp. closets	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
5-42	325	Halls and Common areas	CF23/1- scrw	2	0	0.023	0.046	CF13/1- scrw	2	0.013	0.026	breaker	yes	
5-42a	326	24 Hour - Exit	EI15/2	1	0	0.030	0.030	ELED2/2	1	0.009	0.009	breaker	yes	
5-43	327	Storage, comp. closets	I75/1	1	0	0.075	0.075	CF23/1- scrw	1	0.023	0.023	switch	yes	tele. Rm.
5-44	328	Storage, comp. closets	I75/1	1	0	0.075	0.075	CF23/1- scrw	1	0.023	0.023	switch	yes	elec. Rm.
5-45	329	Storage, comp. closets	I75/1	1	0	0.075	0.075	CF23/1- scrw	1	0.023	0.023	switch	yes	closet

4-1	330	Common Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
4-2	331	Storage, comp. closets	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
4-3	332	Closed Office Areas	F44ES	5	0	0.144	0.720	F44ILL-R	5	0.102	0.510	switch	yes	
4-4	333	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
4-5	334	Closed Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
4-6	335	Common Office Areas	F44ES	5	0	0.144	0.720	F44ILL-R	5	0.102	0.510	switch	yes	
4-7	336	Common Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
4-8	337	Common Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
4-9	338	Storage, comp. closets	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	storage
4-10	339	Common Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
4-10a	340	Common Office Areas	I65/1	1	0	0.065	0.065	CF13/1 - scrw	1	0.013	0.013	switch	yes	
4-11	341	Common Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
4-12	342	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
4-13	343	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
4-14	344	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
4-15	345	Common Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
4-16	346	Closed Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
4-16a	347	Closed Office Areas	I75/1	5	0	0.075	0.375	CF13/1 - scrw	5	0.013	0.065	dimmer	yes	
4-17	348	Common Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	vacant
4-18	349	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	vacant
4-19	350	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	vacant
4-20	351	Common Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
4-21	352	Closed Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	copy
4-22	353	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
4-23	354	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
4-24	355	Halls and Common areas	CF23/1 - scrw	3	0	0.023	0.069	CF13/1 - scrw	3	0.013	0.039	breaker	yes	
4-24a	356	24 Hour - Exit	EI15/2	1	0	0.030	0.030	ELED2/2	1	0.009	0.009	breaker	yes	
4-25	357	Halls and Common areas	F41ES	3	0	0.048	0.144	F41ILL	3	0.031	0.093	switch	yes	restroom
4-26	358	Halls and Common areas	F41ES	2	0	0.048	0.096	F41ILL/T2	2	0.030	0.060	switch	yes	restroom
4-26	359	Halls and Common areas	F41ES	2	0	0.048	0.096	F41ILL	2	0.031	0.062	switch	yes	restroom
4-27	360	Storage, comp. closets	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	film storage
4-28	361	Storage, comp. closets	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	elec. Rm.
4-31	362	Common Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
4-32	363	Common Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	comp. rm
4-33	364	Closed Office Areas	I60/1	4	0	0.060	0.240	CF13/1 - scrw	4	0.013	0.052	switch	yes	MRI room type 2

4-33	365	Closed Office Areas	I100/1	4	0	0.100	0.400	CF13/1- scrw	4	0.013	0.052	switch	yes	MRI room type 2
4-34	366	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
4-34a	367	Closed Office Areas	I100/1	2	0	0.100	0.200	CF13/1- scrw	2	0.013	0.026	switch	yes	
4-34a	368	Closed Office Areas	I100/1	2	0	0.100	0.200	CF13/1- scrw	2	0.013	0.026	switch	yes	
4-35	369	Common Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
4-36	370	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
4-37	371	Closed Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
4-38	372	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
4-39	373	Closed Office Areas	FU2SE	4	0	0.072	0.288	FU2LL	4	0.060	0.240	switch	yes	
4-39a	374	Closed Office Areas	I120/1	1	0	0.120	0.120	CF13/1- scrw	1	0.013	0.013	dimmer	yes	
4-40	375	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
4-41	376	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
4-42	377	Closed Office Areas	FU2SE	4	0	0.072	0.288	FU2LL	4	0.060	0.240	switch	yes	very difficult / X-ray room
4-42a	378	Closed Office Areas	I75/1	1	0	0.075	0.075	CF13/1- scrw	1	0.013	0.013	switch	yes	
4-43	379	Storage, comp. closets	I100/1	1	0	0.100	0.100	CF13/1- scrw	1	0.013	0.013	switch	yes	
4-44	380	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
4-45	381	Common Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
4-46	382	Common Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	lockeroom
4-47	383	Common Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	lockeroom
4-48	384	Storage, comp. closets	I15/1	1	0	0.015	0.015	CF13/1- scrw	1	0.013	0.013	switch	yes	
4-49	385	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
4-50	386	Common Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	lockeroom
4-51	387	Common Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	lockeroom
4-52	388	Closed Office Areas	FU2SE	4	0	0.072	0.288	FU2LL	4	0.060	0.240	switch	yes	very difficult / X-ray room
4-52	389	Closed Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	very difficult / X-ray room
4-52a	390	Closed Office Areas	I75/1	1	0	0.075	0.075	CF13/1- scrw	1	0.013	0.013	switch	yes	dimmeer switch works as a switch type 1
4-53	391	Storage, comp. closets	I100/1	1	0	0.100	0.100	CF13/1- scrw	1	0.013	0.013	switch	yes	
4-54	392	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
4-55	393	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
4-55a	394	Closed Office Areas	I75/1	1	0	0.075	0.075	CF13/1- scrw	1	0.013	0.013	switch	yes	
4-56	395	Closed Office Areas	F44ES	5	0	0.144	0.720	F44ILL-R	5	0.102	0.510	switch	yes	
4-56s	396	Closed Office Areas	F44ES	5	0	0.144	0.720	F44ILL-R	5	0.102	0.510	switch	yes	

4-57	397	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
4-57a	398	Closed Office Areas	I75/1	1	0	0.075	0.075	CF13/1- scrw	1	0.013	0.013	switch	yes	
4-57b	399	24 Hour - Misc	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	breaker	yes	
4-58	400	Common Office Areas	F44ES	7	0	0.144	1.008	F44ILL-R	7	0.102	0.714	switch	yes	
4-59	401	Common Office Areas	F44ES	11	0	0.144	1.584	F44ILL-R	11	0.102	1.122	switch	yes	
4-59a	402	24 Hour - Exit	EI15/2	2	0	0.030	0.060	ELED2/2	2	0.009	0.018	breaker	yes	
3-1	403	Common Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	café
3-2	404	Common Office Areas	F44ES	6	0	0.144	0.864	F44ILL-R	6	0.102	0.612	switch	yes	café
3-3	405	Common Office Areas	F44ES	10	0	0.144	1.440	F44ILL-R	10	0.102	1.020	switch	yes	café
3-4	406	Common Office Areas	F44ES	8	0	0.144	1.152	F44ILL-R	8	0.102	0.816	switch	yes	kitchen
3-5	407	Storage, comp. closets	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
3-6	408	Storage, comp. closets	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
3-7	409	Storage, comp. closets	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
3-8	410	Storage, comp. closets	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	mail rm.
3-11	411	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
3-12	412	Closed Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
3-14	413	Storage, comp. closets	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
3-15	414	Common Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
3-16	415	Closed Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
3-17	416	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	break room
3-18	417	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
3-19	418	Common Office Areas	F44ES	14	0	0.144	2.016	F44ILL-R	14	0.102	1.428	switch	yes	
3-20	419	Common Office Areas	I150/1	5	0	0.150	0.750	CF13/1- scrw	5	0.013	0.065	switch	yes	
3-20	420	Common Office Areas	F24SS	1	0	0.112	0.112	F22LL-R	1	0.028	0.028	switch	yes	
3-20	421	Common Office Areas	F44ES	5	0	0.144	0.720	F44ILL-R	5	0.102	0.510	switch	yes	
3-20a	422	24 Hour - Exit	EI15/2	1	0	0.030	0.030	ELED2/2	1	0.009	0.009	breaker	yes	
3-21	423	Common Office Areas	I52/1	8	0	0.052	0.416	CF13/1- scrw	8	0.013	0.104	switch	yes	
3-21a	424	24 Hour - Exit	EI15/2	1	0	0.030	0.030	ELED2/2	1	0.009	0.009	breaker	yes	
3-22	425	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
3-22a	426	Common Office Areas	I52/1	4	0	0.052	0.208	CF13/1- scrw	4	0.013	0.052	switch	yes	hard ceiling
3-22b	427	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
3-22c	428	Common Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
3-22d	429	Common Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
3-23	430	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
3-24	431	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
3-25	432	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
3-26	433	Common Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	

3-26a	434	24 Hour - Exit	EI15/2	1	0	0.030	0.030	ELED2/2	1	0.009	0.009	breaker	yes	
3-27	435	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
3-28	436	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
3-29	437	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
3-30	438	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
3-31	439	Halls and Common areas	F41ES	2	0	0.048	0.096	F41ILL	2	0.031	0.062	switch	yes	restroom
3-31	440	Halls and Common areas	F41ES	2	0	0.048	0.096	F41ILL/T2	2	0.030	0.060	switch	yes	restroom
3-32	441	Halls and Common areas	F41ES	3	0	0.048	0.144	F41ILL	3	0.031	0.093	switch	yes	restroom
3-33	442	Halls and Common areas	CF23/1-scrw	3	0	0.023	0.069	CF13/1-scrw	3	0.013	0.039	breaker	yes	
3-33a	443	24 Hour - Exit	EI15/2	1	0	0.030	0.030	ELED2/2	1	0.009	0.009	breaker	yes	
3-34	444	Common Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
3-35	445	Common Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
3-36	446	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
3-37	447	Common Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
3-38	448	Common Office Areas	F44ES	8	0	0.144	1.152	F44ILL-R	8	0.102	0.816	switch	yes	
3-39	449	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
2-1	450	Common Office Areas	F44ES	9	0	0.144	1.296	F44ILL-R	9	0.102	0.918	switch	yes	
2-1a	451	24 Hour - Misc	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	breaker	yes	
2-2	452	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
2-3	453	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
2-4	454	Common Office Areas	F44ES	19	0	0.144	2.736	F44ILL-R	19	0.102	1.938	switch	yes	
2-5	455	Common Office Areas	F24SS	1	0	0.112	0.112	F22LL-R	1	0.028	0.028	switch	yes	
2-6	456	Common Office Areas	F44ES	19	0	0.144	2.736	F44ILL-R	19	0.102	1.938	switch	yes	
2-7	457	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
2-8	458	Common Office Areas	F44ES	10	0	0.144	1.440	F44ILL-R	10	0.102	1.020	switch	yes	
2-9	459	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
2-10	460	Closed Office Areas	F44ES	6	0	0.144	0.864	F44ILL-R	6	0.102	0.612	switch	yes	
2-11	461	Common Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
2-12	462	Common Office Areas	F44ES	17	0	0.144	2.448	F44ILL-R	17	0.102	1.734	switch	yes	
2-12	463	Common Office Areas	F41ES	5	0	0.048	0.240	F41ILL	5	0.031	0.155	switch	yes	
2-13	464	Common Office Areas	F41ES	1	0	0.048	0.048	F41ILL	1	0.031	0.031	switch	yes	
2-13	465	Common Office Areas	F31ES	1	0	0.042	0.042	F31ILL-R	1	0.027	0.027	switch	yes	
2-14	466	Closed Office Areas	F44ES	6	0	0.144	0.864	F44ILL-R	6	0.102	0.612	switch	yes	
2-15	467	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
2-16	468	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
2-17	469	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
2-18	470	Closed Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	

2-19	471	Conference Rooms	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
2-20	472	Storage, comp. closets	I75/1	2	0	0.075	0.150	CF23/1-scrw	2	0.023	0.046	switch	yes	
2-21	473	Storage, comp. closets	F44ES	22	0	0.144	3.168	F44ILL-R	22	0.102	2.244	switch	yes	
2-22	474	Conference Rooms	I75/1	7	0	0.075	0.525	CF13/1-scrw	7	0.013	0.091	dimmer	yes	
2-22a	475	Conference Rooms	I75/1	6	0	0.075	0.450	CF13/1-scrw	6	0.013	0.078	dimmer	yes	
2-22b	476	Conference Rooms	I75/1	6	0	0.075	0.450	CF13/1-scrw	6	0.013	0.078	dimmer	yes	
2-22c	477	Conference Rooms	I150/1	2	0	0.150	0.300	CF13/1-scrw	2	0.013	0.026	switch	yes	
2-22d	478	Conference Rooms	I75/1	2	0	0.075	0.150	CF13/1-scrw	2	0.013	0.026	switch	yes	
2-23	479	Storage, comp. closets	F42ES	2	0	0.082	0.164	F42ILL-R	2	0.052	0.104	switch	yes	
2-25	480	Halls and Common areas	CF23/1-scrw	3	0	0.023	0.069	CF13/1-scrw	3	0.013	0.039	breaker	yes	
1-1	481	Closed Office Areas	F42ES	2	0	0.082	0.164	F42ILL-R	2	0.052	0.104	switch	yes	
1-1	482	Closed Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
1-1a	483	24 Hour - Misc	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	breaker	yes	
1-2	484	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
1-3	485	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
1-4	486	Common Office Areas	F44ES	9	0	0.144	1.296	F44ILL-R	9	0.102	0.918	switch	yes	
1-5	487	Common Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
1-5a	488	Common Office Areas	F44ES	5	0	0.144	0.720	F44ILL-R	5	0.102	0.510	dimmer	yes	
1-5b	489	Common Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
1-6	490	Common Office Areas	F44ES	3	0	0.144	0.432	F44ILL-R	3	0.102	0.306	switch	yes	
1-7	491	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	
1-8	492	Common Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	
1-9	493	Common Office Areas	F44ES	5	0	0.144	0.720	F44ILL-R	5	0.102	0.510	switch	yes	
1-10	494	Common Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
1-11	495	Common Office Areas	F41ES	2	0	0.048	0.096	F41ILL	2	0.031	0.062	switch	yes	
1-12	496	Common Office Areas	F41ES	2	0	0.048	0.096	F41ILL	2	0.031	0.062	switch	yes	
1-13	497	Common Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	
1-14	498	Common Office Areas	F44ES	8	0	0.144	1.152	F44ILL-R	8	0.102	0.816	switch	yes	vault
1-14	499	Common Office Areas	FU2ES	4	0	0.072	0.288	FU2LL	4	0.060	0.240	switch	yes	vault
1-15	500	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	12' ladder
1-16	501	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	12' ladder
1-17	502	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	12' ladder
1-18	503	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	12' ladder
1-19	504	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	12' ladder
1-21	505	Closed Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	12' ladder

1-21a	506	Storage, comp. closets	I75/1	3	0	0.075	0.225	CF13/1-scrw	3	0.013	0.039	switch	yes	
1-21b	507	Storage, comp. closets	I75/1	3	0	0.075	0.225	CF13/1-scrw	3	0.013	0.039	switch	yes	
1-22	508	Closed Office Areas	F44ES	4	0	0.144	0.576	F44ILL-R	4	0.102	0.408	switch	yes	12' ladder
1-22a	509	Closed Office Areas	I75/1	3	0	0.075	0.225	CF13/1-scrw	3	0.013	0.039	switch	yes	
1-22b	510	Closed Office Areas	I75/1	3	0	0.075	0.225	CF13/1-scrw	3	0.013	0.039	switch	yes	
1-23	511	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	12' ladder
1-24	512	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	12' ladder
1-25	513	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	12' ladder
1-26	514	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	12' ladder
1-27	515	Common Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	12' ladder
1-27	516	Common Office Areas	F31ES	3	0	0.042	0.126	F31ILL-R	3	0.027	0.081	switch	yes	12' ladder
1-28	517	Closed Office Areas	F44ES	1	0	0.144	0.144	F44ILL-R	1	0.102	0.102	switch	yes	12' ladder
LL-1	518	Storage, comp. closets	F42sS	4	0	0.072	0.288	F42LL-H	4	0.070	0.280	switch	yes	
LL-1	519	Storage, comp. closets	F42sS	8	0	0.072	0.576	F42LL-H	8	0.070	0.560	switch	yes	
LL-2	520	Storage, comp. closets	F42sS	4	0	0.072	0.288	F42LL-H	4	0.070	0.280	switch	yes	
LL-3	521	Closed Office Areas	F44ES	2	0	0.144	0.288	F44ILL-R	2	0.102	0.204	switch	yes	ENGINEERS OFFICE
LL-4	522	Storage, comp. closets	F42ES	1	0	0.082	0.082	F42ILL/T4	1	0.056	0.056	switch	yes	1ST FLOOR AIR ROOM
LL-5	523	Storage, comp. closets	F42ES	3	0	0.082	0.246	F42ILL-R	3	0.052	0.156	switch	yes	
LL-6	524	Storage, comp. closets	F42ES	2	0	0.082	0.164	F42ILL-R	2	0.052	0.104	switch	yes	
SW-1	525	24 Hour - Misc	F42ES	23	0	0.082	1.886	F42ILL-R	23	0.052	1.196	switch	yes	STAIRWELL
SW-2	526	24 Hour - Misc	F42ES	21	0	0.082	1.722	F42ILL-R	21	0.052	1.092	switch	yes	STAIRWELL
					Total kW		220.66			Total kW		147.82		

ATTACHMENT 2: M&V EQUIPMENT CUT SHEETS

BOBO Lighting Loggers

Dos Bobos Data Systems

Colorado Springs, CO

Lighting Logger model BOBO-L-TOU

Hardware features:

- Records time of on/off transition
- Accuracy of one minute
- Delayed start
- Sensitivity adjustment
- Memory records up to 2,048 observations
- Communicates with computer via RS-232 interface
- Battery life of one year
- Magnet mount, fits in most fixtures

Software features:

- Communicates with loggers via RS-232 interface
- Adjusts logger clock when initializing
- Displays data in text and graphical format
- Provides on-time summary by time-of-use period
- Can export data in Excel and 1-2-3 format for further analysis

Elite Instruments

Philadelphia, PA

Elite 6-channel recorder

Hardware Features

- Modules available for a variety of physical measurements
- Platinum RTD temperature probes for 0.5% accuracy (matched sensor pairs available)
- Paddle-wheel flow sensor for 5% accuracy- requires 1" NPT port
- True-Power module measures 3-phase voltage and current- converts to single analog signal.
- Battery-operated for reliable operation
- Communicates with computer via RS-232 port

Software Features

- Communicates with recorder via RS-232 port
- Extensive data analysis capabilities
- Can export data to Excel and 1-2-3 format.

ACME Meters

Needles, AZ

Single-phase power meter Model 40

Features:

Clamp-on current sensor

3 1/2 digits

Measures voltage, current, kVA, kW, PF

Battery operated

2% accuracy